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LOWER CRETACEOUS FORAMINIFERA OF
THE ORCHARD PEAK-DEVILS DEN AREA,
CALIFORNIA

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The microfaunas of the lower Cretaceous of California have received very little attention from micropaleontologists in the past and only in recent years has anything been published about them. This has been partly because of a lack of economic interest in this part of our extensive Cretaceous section, in part to its limited areal extent when compared to the more widespread upper Cretaceous, and possibly, in a large measure, to the fact that well-preserved faunas are scarce in many of the better known outcrop sections. With regard to the macro fossils the opposite of this situation has prevailed. Numerous papers on the stratigraphy and paleontology of the lower Cretaceous have appeared from the beginning of geologic work in California. The most recent paper describing lower Cretaceous beds in the area under consideration, is by Owen T. Marsh (1960). In it Marsh names and describes in detail seven new formations. One of the lower formations, the Badger shale, is questionably listed as of lower Cretaceous age. A limited outcrop of serpentine is within or in fault contact with the Badger at its base. Below the Badger shale in structural discordance, is the Hex formation which Marsh, with considerable doubt, assigns to the late Jurassic. The doubtful assignment was based on the identification of belemnites by Professor Leslie Baristow of the British Museum of Natural History and Dr. J. A. Jeletzky of the Geological Survey of Canada. Professor Baristow suspected the belemnites were of late Jurassic age but stated that his conclusions were only provisional. Dr. Jeletzky's opinion was quoted as follows, "... the following suggestions are to be considered quite tentative. It would

appear to me that the fragment belongs to a large and sturdy *Belemnopsis* probably of the group of *Belemnopsis sulcatus* Phillips or *Belemnopsis gerardi* . . . Its being of the group of Indo-Pacific *Belemnopsis gerardi* Oppel, 1863 . . . appears to be more probable . . . Should the above assumption be correct . . . upper Jurassic age would be indicated for the beds containing it." Marsh further stated that a different opinion of the age was reached by John P. Wagner whose MS. thesis (University of California, 1947) deals with the geology of the Sawtooth Ridge Quadrangle. One of the several species of belemnites found in the Hex formation was identified by Dr. J. Wyatt Durham of the University of California at Berkeley, as *Acroteuthis winslowensis* Anderson, 1938. This identification was subsequently confirmed by Dr. J. A. Jeletzky who stated that the form should be, "tentatively assigned to early to mid-lower Cretaceous (not younger than Barremian, though)."

In a further attempt to determine the age of the Hex formation, Marsh collected samples for microfossil determinations and submitted them to Mr. J. D. Bainton of the Standard Oil Company laboratory for study. Both radiolarians and foraminifera were found and these, mostly long ranging species, were tentatively considered to be of late Cretaceous age. However, the concluding statement by Bainton was that, "the fauna is not definitely definitive of age and therefore the age assignments . . . should not be considered conclusive." Thus faced with three possible age assignments for the Hex, Marsh concluded, "It is possible that all three ages are represented by the Hex, but this possibility cannot as yet be proved because none of the age assignments can be stated as being conclusive. For the sake of convenience, the Hex formation will be designated provisionally in this report as upper Jurassic (?)."

In the Devils Den outcrop the Hex formation is in fault contact with Eocene and Miocene at its eastern extremity and probably Eocene and Paleocene at the west where its limits are not so clearly defined. In the Hex Hill occurrence both folding and faulting appear to account for the outcrop which extends over a much wider area than the more easterly outcrop. In describing the Hex Hill exposure Marsh stated, "The Hex formation crops out east of Orchard Peak as a single band about a half mile wide and more than four miles long, paralleling the base of the scrap formed by Avenal Ridge. The unit occupies the core of the Avenal Ridge piercement anticline. Apparently the soft, plastic shales of the Hex formation, originally at an unknown depth below their present position, were squeezed up through the overlying formation during folding and thrust faulting of the Avenal Ridge anticline." In whatever way this extensive body of plastic clay arrived at its present position, there are very few contrasting beds of silt or sand to suggest a structural pattern. In only one small area, in a deep gully in the central part of the Devils Den proper, have beds been found which show definite stratification. Here the strike is approximately north-south which is at right angles to the Eocene and Miocene on its north and south

flanks. As most of the Hex formation is a massive claystone with little evidence of bedding, the only relief from its sameness are the occasional outcrops of lenses and pods of impure, whitish to buff limestone which, because of its superior resistance to weathering, stands out above the clays. It is these limy masses which have yielded the few ammonites found. They also contain numerous radiolaria and occasional foraminifera. Belemnites have also been found in them in rare instances but most of these weather out of the clay and occur as fragments on the rain-washed surface.

Foraminifera were found in virtually all fresh samples of the clay but in many of them only arenaceous species were present.

HISTORY OF PRESENT WORK

From August to October of 1932, Mr. F. A. Menken, then a field geologist with the Associated Oil Company (later Tidewater Oil Company), made a geologic study of the Devils Den—Orchard Peak area and mapped the various geologic units. From time to time during the course of his work he submitted macrofossil and microfossil samples to the laboratory for identification and age determination. Among the samples were a few soft claystone samples from the deeply dissected, low, rounded hills long known as Devils Den, and from the smoothly contoured, flat-topped clay hill on the southeast slope of Orchard Peak, more recently named Hex Hill by Marsh. These samples yielded foraminifera which were new to our experience in California foraminifera, but from their similarities with faunas from the lower Cretaceous of Europe and Texas and the association with the belemnites, they were tentatively considered to be of lower Cretaceous age. Because of our uncertainty as to the age of the fauna and its unusual character, Dr. G. D. Hanna, then senior Paleontologist for the company, and the author, accompanied by J. B. Stevens, went to the Devils Den—Orchard Peak area with the hope of finding more conclusive evidence for the age. Samples of claystone were collected at Devils Den and from the claystone hill on the eastern flank of Orchard Peak. These samples later yielded foraminifera similar to those collected by Mr. Menken. In the Hex formation belemnites like those from Devils Den were found along with a single ammonite of the genus *Lytoceras* which Dr. F. M. Anderson later named *Lytoceras saturnale*. A few aucellas were also found which Dr. Anderson identified as *Aucella solida* Lahusen and *A. inflata* Toula, all known to him from the lower Cretaceous Paskenta beds of the Shasta Series. This was our first definite indication of the true age of these beds. In his paper (Anderson, 1938, p. 105) on the lower Cretaceous deposits in California and Oregon, he made the following statement regarding *Aucella solida*. "This species has been found with *A. inflata*, *A. uncitoides* and *Lytoceras saturnale* nov., in the lower beds of the Paskenta group in the type district, and in the same horizon in the Devils Den district, Kern County, where it was collected by Hanna and Church."

More recently (1962-1964), the author made several visits to the area which permitted a more detailed examination of the outcrop and more extensive and selective sampling of the clays and fossils. Two more specimens of the ammonite species, *Lytoceras saturnale*, were found in the Devils Den outcrop as well as an aucella and a better preserved collection of belemnites. A good series of the clays were collected from both Devils Den and Hex Hill which furnished a wide variety of well preserved foraminifera. These faunas were similar to those collected at the earlier date but in the variety of species, far exceeded any previously collected. The microfaunas from the two areas were studied and compared and while many species are common to the two areas, there are some notable differences in the two faunas. A number of distinctive species from no. 7 of Hex Creek have not been found at Devils Den and some equally distinctive species found at Devils Den have not been found at Hex Creek, a circumstance possibly due to insufficient sampling. It does seem quite certain, however, that with the number of species, both calcareous and arenaceous, common to the two areas, the formations are of essentially the same age. This belief is further strengthened by the fact that such uncommon species as the new genus *Menkenina* and certain species of *Citharina* are found at both localities. Also, as has been mentioned earlier in the text, the same species of macrofossils, have been found at both outcrops and these well authenticated time markers are the key to the age of the Hex. As indicated earlier, the isolated nature of the Hex formation offers little opportunity for an age assignment from its relationships with contiguous beds of established zones and ages. The beds in fault contact with it are from upper to possibly lower Cretaceous but Marsh had no definite proof of the true age of the Badger shale which is the oldest of the strata pierced by the Hex. Foraminifera from the lowest part of the Serpiente formation in fault contact with the Hex are G-2 (Turonian) in age but according to Marsh's mapping this would be in the upper few hundred feet of the formation. The determination of the exact age of the Hex formation therefore must be decided entirely on the basis of the fossils found in it. Marsh placed the age of the Hex formation in the Jurassic with considerable doubt, for reasons already stated but apparently was not aware of Anderson's identification of the ammonite and the aucellas, all of which had been found previously in the lower Paskenta group of the type district in northern California. In the light of Anderson's age assignment, it now seems more significant that J. Wyatt Durham identified the belemnite found by John P. Wagner in the Hex formation, as *Acroteuthis winslowensis* Anderson, a lower Cretaceous species. In the present study of the Foraminifera many species were identified from the Valanginian of Europe but some do range much higher. It was apparent early in the study that a Jurassic age could be ruled out and further comparisons indicated rather strongly that a correlation with the Valanginian, as suggested by the macrofossils, was the most likely possibility.

This view is supported in a recent study of the aucellas (now called buchias), by Dr. Ralph W. Imlay of the United States National Museum. He critically examined numerous suites of the genus from Pacific Coast states, particularly Alaska and California, the express purpose of his study being to determine the validity of the numerous named species, many of which were described from single localities. Of particular import to the present problem, to determine the age of the Hex formation, is his conclusion concerning the species *Aucella crassicolis* Keyserling. As stated earlier, Anderson identified the two species of *Aucella* from the beds containing the ammonite, *Lytoceras saturnale*, as *A. solida* Lahusen and *A. inflata* Toulua. Both of these species, as well as *A. uncitoides* Pavlow, are considered by Imlay to be named variations of a single species, *A. crassicolis* Keyserling. In his range chart of the various species of *Aucella*, Imlay places this species in the upper two-thirds of the Valanginian of the lower Cretaceous, where it is often abundant, but he does not show it ranging above this zone into the Hauterivian. This opinion of the age level of *A. crassicolis* appears to be shared by Dr. J. A. Jeletzky who examined the Hex Hill-Devils Den macrofossils at the California Academy of Sciences in San Francisco, California, 23 November 1966. He identified the buchias [aucellas] from the Hex formation as being of the *B. crassicolis* group and illustrated, by means of a chart (information received by Dr. L. G. Hertlein, of the Academy's Department of Geology), that *Buchia crassicolis*, *B. inflata*, and *B. solida* were of the uppermost Valanginian but not extending above that stage. Anderson (1932, p. 103) also stated that, "They [*Aucella crassicolis*] are not known to occur in any part of the Knoxville series (upper Jurassic) or in any beds later than Paskenta," again placing an upper limit on the species. If these specialists in the field of lower Cretaceous fossils are correct in their opinions, that *Aucella crassicolis* Keyserling is confined to the Valanginian stage, at least on the Pacific Coast of North America, and there seems little reason to doubt it, then the Hex formation must be accepted as being of upper Valanginian equivalence. From a historical viewpoint the finding of fossils of lower Cretaceous age here should cause little surprise because, as far back as 1910, Paskenta fossils (then called Knoxville), were reported found in McLure Valley, only a few miles northeast of Devils Den by Arnold and Anderson (1910). The most significant fossil reported found was *Aucella crassicolis* Keyserling. A few years later Dr. G D. Hanna found the same species in this locality. The clay shale in which the aucellas were found is very similar to that at Devils Den and Hex Hill but it yielded no foraminifera.

RECENT ZONATION OF THE LOWER CRETACEOUS

At the time of the first reading of this paper in Bakersfield, California, 1 April 1965 (Fortieth Annual Meeting of the Pacific Section, American Association of Petroleum Geologists, Society of Exploration Geophysicists and Society of Eco-

EUROPEAN STAGE CLASSIFICATION		FORAMINIFERAL ZONATION GOUKOFF, A-N ZONES BERRY, I-M ZONES		F. M. ANDERSON WESTSIDE TERMINOLOGY 1943		SOUTH AND CENTRAL SACRAMENTO VALLEY KIRBY, ETC.		CHUBER CLASSIFICATION FRUTO QUAD		NORTH END SACRAMENTO VALLEY OND AREA MURPHY, RNDODA AND PETERSON		REDDING AREA POPENDE				
UPPER CRETACEOUS	SENOVIAN	CAMPANIAN	F-1 ZONE	PANOCHE GROUP	CHICO SERIES	FORBES FM	GUINDA FM	GAS POINT MEMBER	BALD HILLS MEMBER	CHICKABOLLY MEMBER	BUDDEN CANYON FORMATION	OGG MEMBER	RECTOR CONGLOM MEMBER			
		SANTONIAN	F-2 ZONE			GUINDA FM	MEMBER VI SHALE									
		CONIACIAN	G-1 ZONE			FUNKS FM	MEMBER V SAND									
	TURONIAN	G-2 ZONE	PIONEER GROUP	SITES FM	YOLO FM	MEMBER IV SHALE										
		H "w" BIOFACIES H "e" BIOFACIES		VENADO FM	VENADO FM AND FRUTO SS TONGUE	MEMBER III SAND										
	CENOMANIAN	I ZONE	"ANTELOPE SHALE" (ITALIAFERRO)	CLARK VALLEY MUOSTONE	MEMBER II SHALE											
	?	PLECTINA SUBZONE	"SALT CREEK" CONGLOM	JULIAN ROCKS FORMATION	MEMBER I SAND											
	LOWER CRETACEOUS	ALBIAN	J-1 ZONE	NEW GENUS SP 19 SUBZONE	SHASTA SERIES	HORSETOWN GROUP	SHASTA SERIES	HORSETOWN GROUP	ASPILCHE FORMATION	CHICKABOLLY MEMBER	BUDDEN CANYON FORMATION	OGG MEMBER	RECTOR CONGLOM MEMBER			
														EPISTOMINA SP 10 SUBZONE		
		APTIAN	J-2 ZONE	WINTUN FORMATION												
NEOCOMIAN		K ZONE	PASKENTA GROUP	PASKENTA GROUP										SANHEDRIN FORMATION	KLAMATH COMPLEX	
																BARREMIAN
																HAUTERIVIAN
VALANGINIAN		L ZONE														
BERRIASIAN ?																
TITHONIAN OR PORTLANDIAN	M ZONE	KNOXVILLE SERIES	KNOXVILLE SERIES													

FIGURE 1. Chart showing foraminiferal zonation, late Mesozoic of the Sacramento Valley, California. Chart reproduced through the courtesy of Keith D. Berry, Standard Oil Company, Oildale, California.

nomic Paleontologists), a paper was presented by Mr. Keith D. Berry on, "New Foraminiferal Zonation, upper Mesozoic, Sacramento Valley, California." This paper was based on a detailed study of a large number of surface and well samples from the upper Jurassic Knoxville to the base of the upper Cretaceous where the established zones of Goudkoff were encountered. In this study Berry described and named six new zones, I, J1, J2, K, L, M, extending the zonation of Goudkoff downward from the base of the upper Cretaceous to the upper Jurassic. He also established more definite criteria for the "H" Zone of Goudkoff and defined its limits, placing it on a par with the other more adequately defined zones. In naming the new zones he continued the alphabetical system begun by Goudkoff. Zone I to L embrace the lower Cretaceous and M the upper Jurassic, Tithonian.

In the abstract of his paper he stated that the K, L, and M Zones are "more difficult to differentiate, because of the absence of planktonics and the predominance of many similar *Nodosariidae*." The latter part of this statement is strikingly descriptive of the Devils Den faunas which are largely composed of *Nodosariidae*. The statement about the "absence of planktonics" however, does not apply as several species were found in the Hex Hill fauna. This may be because of better preservation of the fossils in the Hex Hill and its quick and complete disintegration in water in preparing samples for study. Berry's new zones are approximately correlated with the European stages on the basis of both benthonic and planktonic foraminifera and where possible, tied in to the known macrofossil localities which had been equated with the European standard section. Where uncertainties existed between zones he inserted question marks to allow for them. This new zonation, based on normal, relatively undisturbed lower Cretaceous and upper Jurassic sections, presented the first available opportunity for a comparison of the Hex Hill-Devils Den faunas with an established lower Cretaceous stratigraphic and faunal sequence. Through the considerate cooperation of Mr. Berry, a comparison was made between faunas of the Hex formation and those from the Sacramento Valley sections. In this examination a fauna was found which contained some of the more distinctive species common to the Devils Den faunas. It is representative of Berry's K Zone which he believed to be of Hauterivian, Barremian equivalence. The rich fauna of Hex Creek no. 7 was not recognized among Berry's slides but he was of the opinion that it represented beds younger than those at Devils Den. This determination of the age is at variance with Anderson's and Jeletzky's placement of the macrofossils of the Hex Hill in the Valanginian, but the foraminiferal comparisons were admittedly brief and more detailed work and comparisons of these lower Cretaceous faunas may reveal the reasons for the apparent difference in correlation. From the variations now known to exist in the Hex Hill faunas it may be found that some part of it is younger than the upper Valanginian.

DISTINGUISHING FEATURES OF THE HEX HILL FAUNA

There are many features about this fauna which serve to distinguish it from the later Cretaceous of the Pacific Coast, some of the more important being, (1) The great preponderance of the *Nodosariidae* (*Lagenidae*), number at least 50 of the listed species and many more if all the *nodosarias* not listed were to be included; (2) The small number of planktonic species present and their small size; (3) The presence of genera not found in the upper Cretaceous of California; (4) The similarity of the fauna with that of the lower Cretaceous Valanginian of Northwestern Germany and Trinidad, British West Indies; (5) Also the presence of genera and species heretofore not described from California. Of the 88 species listed, 69 are calcareous and 19 arenaceous. The few, small pelagic species were found in only a few places but are usually quite common when

present. There are at least seven rotaloid genera present and where they occur they are usually quite common.

Of the other microfossils, radiolarians are quite abundant in the limestone masses and more rarely they may be common in the clays. Ostracods are very rare and small. Minute carbonaceous fragments are occasionally quite abundant so it is probable that spores and pollen are also present. The claystones have not, to my knowledge, been examined for the smaller microfossils such as discoasters, coccoliths or hystrichospherida. The limestone was examined for diatoms by Dr. G. D. Hanna but not one was found.

ACKNOWLEDGMENTS

In the preparation of this paper I am especially indebted to Dr. and Mrs. G. D. Hanna of the California Academy of Sciences. This applies not only for the preparation of photographic plates but to never-failing encouragement and assistance in many other ways. To Mrs. Hanna I owe my special thanks for her expert illustration of the fauna. Her accurate and detailed drawings of foraminifera have long been known to most paleontologists and recognized as a standard of excellence among illustrators. Without her generous assistance in making the drawings this paper would not have been attempted. Dr. L. G. Hertlein, also of the Geological Department of the California Academy of Sciences, was of great assistance in editorial and technical advice.

I further wish to acknowledge the invaluable assistance of Dr. J. J. Graham of Stanford University, Mr. Keith D. Berry of the Standard Oil Company Laboratory of Oildale, California, and Mr. Andrew W. Marianos of the Humble Oil Company, Los Angeles, California for the loan of rare and hard-to-obtain papers on the lower Cretaceous of Europe, and Mr. Berry and Mr. Marianos for the opportunity of comparing the Hex formation fauna with their large series of slides of the lower Cretaceous from the west side of the Sacramento Valley, California. Mr. E. H. Stinemeyer of the Shell Oil Company, Oildale, California, was of assistance in making a number of color photographs of foraminifera and Mr. A. A. Almgren has been of assistance on field trips and in the loan of comparative material. For the loan of the excellent geologic map of the Devils Den area which was reproduced in their article in Bulletin 118, California Division of Mines and Geology, part 3, I am indebted to Mr. Martin Van Couvering and H. B. Allen. For providing me with an excellent set of foraminiferal samples from the Grayson formation, Grayson Bluff on Denton Creek, Denton County, northern Texas, the locality from which Helen Tappan obtained most of the foraminifera described in her paper on the Grayson formation, I owe my thanks to my nephew and niece, Max and Joan Church of Fort Worth, Texas. Finally, I owe much to the support of the Tidewater Oil Company through many years and for the friendly cooperation of its geologic staff.

CALIFORNIA ACADEMY OF SCIENCES LOCALITIES
DEVILS DEN

Locality 27502 (CAS). Number 49. About 150 feet west and 400 feet north of the south quarter corner of the northeast quarter of Section 20. Township 25 south, Range 18 east of the Mount Diablo base and meridian northwestern Kern County, California. F. A. Menken, collector.

Number 50. About 600 feet west and 100 feet north of center of Section 20, Township 25 south, Range 18 east of the Mount Diablo base and meridian. F. A. Menken, collector.

Locality 40081 (CAS). Head of east-west trending gully, about 800 feet northwest of the center of Section 21, Township 25 south, Range 18 east of the Mount Diablo base and meridian, Kern County, California, Sawtooth Ridge quadrangle, 7.5 minutes, 1935 Edition. C. C. Church, collector.

Number 47. North side of east-west gully above and about 500 feet southwest of first sample. Earlier localities 16196 and 27501 (CAS) same locality, described as "center Section 21, Township 25 south, Range 18 east of the Mount Diablo base and meridian, Devils Den area." F. A. Menken, collector.

Number 48. About 300 feet northwest of no. 47 near head of small side gully. Also listed under 16196 and 27501 (CAS). F. A. Menken, collector.

Locality 40091 (CAS). Station numbers 1 to 8. From deep north-south trending V-shaped gully beginning 500 feet south and 700 feet west of the east quarter corner of Section 20, Township 25 south, Range 18 east of the Mount Diablo base and meridian, Kern County, California. C. C. Church, collector.

Number 1. East bank of gully near base, approximately 75 feet north of gully mouth.

Number 2. About 75 feet up stream north of no. 1, in a straight line.

Number 3. About 30 feet north of no. 2.

Number 4. About 25 feet north of no. 3.

Number 5. About 20 feet north of no. 4.

Number 6. About 50 feet north of no. 5.

Number 7. About 75 feet north of no. 6.

Number 8. From steep east bank of gully about 20 feet south of junction with first northeast trending branch; this is about 600 feet due west of the east quarter corner of Section 20, Sawtooth Ridge quadrangle, 1953 Edition. *Lytoceras saturnale* was found on the side of this gully near station no. 7.

HEX HILL

This flat-topped hill with deeply dissected sides occupies much of the northeast quarter of Section 31 and the northwest quarter of Section 32, Township 25 south, Range 18 east of the Mount Diablo base and meridian, northwestern

Kern County, California. It is terminated on the west side by a deep V-shaped gully which is dry most of the year. This creek has no official name on the topographic sheet but is referred to here as "Hex Creek."

The mouth of this gully is at about the exact center of Section 31 and the creek trends due north upstream a quarter mile, then turns northeast and divides into two branches near the fault contact of the Hex formation and the overlying, well bedded and steeply dipping shale and sandstone of the Serpiente formation of late Cretaceous age. The Sawtooth Ridge, 7.5 minute quadrangle, is the basis for all measurements.

Locality 40092 (CAS). Station no. 1, from west slope of the most easterly deep gully of Hex Hill, about 200 feet north and 400 feet west of center of Section 32, Township 25 south, Range 18 east of the Mount Diablo base and meridian, northwestern Kern County, California. C. C. Church, collector.

Locality 40093 (CAS). Station no. 15, from the upper end of the second west trending side gully from the mouth of the most easterly deep gully of Hex Hill, about 1000 feet west and 200 feet north of center of Section 32. Good foraminiferal fauna similar to no. 7 of Hex Creek, 40095 (CAS). C. C. Church, collector.

Locality 40094 (CAS). Clay test pit, southwestern extremity of Hex Hill about 75 feet east of the mouth of Hex Creek and the center of Section 31. C. C. Church, collector.

Locality 40095 (CAS). Station no. 7, Hex Creek. From the lower slope of a south-facing small ridge projecting into Hex Creek from the west causing it to veer to the northeast, about 1150 feet south and 200 feet east of north quarter corner, Section 31, Township 25 south, Range 18 east of the Mount Diablo base and meridian calcareous and arenaceous foraminifera. Station no. 8, from creek bed about 100 feet north of no. 7 is also included in Locality 40095 (CAS). Fauna same as no. 7. C. C. Church, collector.

Locality 40096 (CAS). Field numbers 10 and 11, late Cretaceous from clay shale bed 3 feet thick above thick bedded sandstone, dipping about 85 degrees north, south side of gully from northwest near bend in Hex Creek and 70 feet up gully from creek. About 1000 feet south and 600 feet east of the north quarter corner, Section 31. Turonian, G-2 stage. C. C. Church, collector.

DESCRIPTION OF FORAMINIFERA

Order FORAMINIFERIDA

Suborder TEXTULARIINA

Superfamily AMMODISCACEA

Family AMMODISCIDAE Reuss, 1862

Subfamily AMMODISCINAE Reuss, 1862

Genus *Ammodiscus* Reuss, 1862

***Ammodiscus glabratus* CUSHMAN and JARVIS, 1928.**

(Plate 7, figure 9.)

Ammodiscus glabratus CUSHMAN and JARVIS, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 86, pl. 12, figs. 6 a, b.

This species occurs commonly in strata of upper Cretaceous and of Paleocene age and seems to be very much the same in the Devils Den-Hex Hill area. It was found at sample localities nos. 1, 2, and 5 of Devils Den and no. 46 (F. A. Menken). At Hex Hill it was found at nos. 1 and 15 and the clay pit near the mouth of Hex Creek.

The same species was described by Lewis Martin in his paper on the upper Cretaceous of the Panoche Hills, Fresno County, California (1964) but he applied the generic name *Involutina*. This use of the generic name, *Involutina*, was, no doubt, due to the confusion which involved the two names for so long. This appears to have been straightened out by the research of A. R. Loeblich and Helen Tappan (1961, p. 187). They conclude that the name *Ammodiscus* applies only to the arenaceous species while *Involutina* includes the calcareous species. This point is stressed here because both genera are present in the Devils Den material and, to this author's knowledge, true *Involutina* has not been previously reported from the early Cretaceous of California. Length .61 mm.

Superfamily LITUOLACEA

Family TROCHAMMINIDAE Schwager, 1877

Subfamily TROCHAMMININAE

Genus *Trochammina* Parker and Jones, 1859

***Trochammina* species.**

(Plate 1, figures 1 a, b, c.)

A fairly common species at nos. 7 and 8 of Hex Creek and no. 15 of Hex Hill but not found at Devils Den.

***Trochammina* species.**

This questionable arenaceous species .84 mm. long, is trochospiral and in shape and arrangement of the chambers similar to the genus *Gyroidina*. It is irregularly flattened on the dorsal side and tapers to a conical point at the base. The chambers are broad and narrow and somewhat longer than wide and the apertural face correspondingly narrow. There are five chambers in the outer whorl and their overlapping at the base forms a conical depression. There is also a rounded pit or depression in the center of the dorsal side. There is a suggestion of a small arched opening or aperture about midway of the base of the apertural face in one or two specimens but in most of them no aperture can be seen.

This is one of the more distinctive species in this fauna but in the literature consulted, nothing like it was found. It was found in only two of the localities at Hex Hill, one at the mud pit near the mouth of Hex Creek in the southwest corner of the northeast quarter of Section 31, Township 25 south, Range 18 east and the other on the west face of a deep gully in the southeast corner of northwest quarter of Section 32, Township 25 south, Range 18 east of the Mount Diablo base and meridian.

Trochammina orchardensis Church, new species.

(Plate 2, figures 11 a, b, c.)

Test free, trochospiral, agglutinated, dorsal side concave with the rim of the final whorl curving upward, surface roughened by irregularly raised chambers and slightly depressed sutures giving the edge a gently scalloped effect; sutures composed of more transparent cementing material, slightly depressed near central areas on the umbilical side, flush with surface or slightly raised on the dorsal side, sutures straight on umbilical side, sharply curved on the dorsal side. The thickness of the test and degree of concavity varies, the concavity on the umbilical side being smoothly rounded and shallow, the dorsal side concave to nearly flat with a rugose surface, there are ten chambers in the final whorl, the aperture appears to be a narrow opening at the base of the final chamber. Length .59 mm. Width .45 mm.

HOLOTYPE no. 12968 (California Academy of Sciences, Department of Geology Type Collection), from Locality 40092 (CAS), from west slope of the most easterly deep gully on Hex Hill, about 200 feet north and 400 feet west of the center of Section 32, Township 25 south, Range 18 east of the Mount Diablo base and meridian, northwestern Kern County, California; C. C. Church, collector; early Cretaceous.

This species has been found at Hex Hill no. 1 and nos. 1 and 5 of Devils Den, also more easterly, no. 46 (F. A. Menken). At Hex Hill it is quite common.

Genus **Glomospira** Rzehak, 1885

Glomospira gordialis (Jones and Parker).

(Plate 1, figure 2.)

Trochammina squamata var. *gordialis* JONES and PARKER, 1860, Quart. Journ. Geol. Soc., vol. 16, p. 304.

Glomospira gordialis CUSHMAN, 1918, U. S. Nat. Mus., Bull. 104, pt. 1, p. 99, pl. 36, figs. 7-9.

Of all the species found in this fauna, the present species is one of the most common. It is also probably one of the longest ranging species as it has been reported from the Silurian to the Recent. It was found in most samples from Devils Den, particularly from stations nos. 1, 5, 8, and no. 46 (F. A. Menken).

It was found at Hex Hill at nos. 1 and 15 and the Clay pit, also no. 3 of Hex Creek. Diameter .25 mm.

Family LITUOLIDAE de Blainville, 1825

Subfamily LITUOLINAE de Blainville, 1825

Genus **Bulbophragmium** Maync, 1952

Bulbophragmium species.

(Plate 2, figure 2.)

This small, arenaceous species would seem to fall in the above genus since it appears to have a cribrate aperture and a bulbous, streptospiral initial stage, the transitional stage to the uniserial is very short and the biserial stage not clearly demonstrated. There are eight to ten uniserial chambers, all very thin and much broader than high, they are rounded to oval in cross section, the increase in diameter with growth is very slight. The test in general, is very similar in appearance to *Ammobaculoides romaensis* Crespin from the lower Cretaceous of Australia except for the aperture.

This is not a common species and so small that it is easily overlooked. It was found in only one sample of the Hex Formation of Hex Hill, Station no. 1 and at nos. 1 and 5 of Devils Den. Length .59 mm.

Genus **Triplasia** Reuss, 1854

Triplasia species.

This very small, arenaceous species is not common in the Hex Formation but was found at stations no. 1 of Hex Hill and no. 46 (F. A. Menken) of Devils Den. It also was found at no. 5 and above in the same canyon. It appears to be uniserial and concave triangular from the beginning and the three edges are beaded and irregular with most tests having a curved and somewhat twisted shape. There is no apparent neck or projection at the apertural end.

Subfamily HAPLOPHRAGMOIDINAE Maync, 1952

Genus **Cribrostomoides** Cushman, 1910

Cribrostomoides species.

A rather robust species, fairly common where it does occur as at stations nos. 3, 4, 6, 7, 8, and 15 of Hex Creek, not found at Devils Den.

This is a very thick, close coiled species, almost completely involute, rounded in cross section, sutures at right angles to periphery, very slightly to moderately depressed, seven to nine chambers to a whorl, aperture obscure but appears to be cribrate, .6 mm. to .7 mm. in diameter composed of fairly coarse sand grains but smoothly finished.

Genus **Haplophragmium** Reuss, 1860**Haplophragmium aequale** (Roemer) 1841.

(Plate 2, figure 10.)

Spirolina aequalis ROEMER 1841, Kreidegeb. 98, pl. 15, fig. 27.*Haplophragmium aequale* Roemer sp., 1863, REUSS, Hils u. Gault, p. 29, pl. 1, figs. 1-7.*Haplophragmium aequale* (Roemer) 1841, BARTENSTEIN, 1952, Senckenbergiana, vol. 33, nos. 4-6, p. 325, pl. 1, figs. 2-11; pl. 2, figs. 17-26; pl. 3, figs. 1-6; pl. 6, figs. 6-8; pl. 7, figs. 1-2.

Of the arenaceous species this one is very common at Devils Den, Stations 1 to 7 and at Hex Hill no. 1. In the paper by Bartenstein (1952), a wide variation in this species is shown. In the present instance the species shows very little variation. Length .48 mm.

Genus **Haplophragmoides** Cushman, 1910**Haplophragmoides** species.

(Plate 1, figures 7 a, b.)

This species is irregular, trochospiral, somewhat compressed and distorted, aperture not apparent, not a common species where it occurs at Hex Hill no. 1. Length .53 mm.

Family ATAXOPHRAGMIIDAE Schwager, 1877

Subfamily GLOBOTEXTULARIINAE Cushman, 1927

Genus **Dorothia** Plummer, 1931*Dorothia* PLUMMER, 1931, Bureau Econ. Geol., Texas Univ., Bull. no. 3101, p. 130.*Marssonella* CUSHMAN, 1933, Cushman Lab. Foram. Res., Contrib., vol. 9, pt. 2, p. 136.**Dorothia oxycona** (Reuss).

(Plate 1, figures 4, 6 a, b.)

Gaudryina oxycona REUSS, 1860, K. Akad. Wiss. Wien, Math.-Naturw. Cl. Sitzungsber, vol. 40, p. 229, pl. 12, fig. 3.*Marssonella oxycona* CUSHMAN, 1933, Cushman Lab. Foram. Res., Contrib., vol. 9, p. 36, pl. 4, fig. 13.*Dorothia oxycona* (Reuss), TRUJILLO, 1960, Jour. Paleo., vol. 34, no. 2, p. 309, pl. 44, figs. 5 a, b.

This widespread and generally long range species is one of the most common forms found in the Devils Den section, particularly in the part from nos. 2 to 6. There is considerable variation in the species from the typical *D. oxycona* to specimens with a wide, flaring, final two chambers and figured as *M. trochus* (d'Orbigny) in a number of papers, e.g., lower Cretaceous of Trinidad by Bartenstein, Bettenstaedt, and Bolli, plate 3, figure 44. Smaller and less typical

specimens were found at station no. 1 of Hex Hill. Length .92 mm. (fig. 4). Length .49 mm. (figs. 6 a, b).

Dorothia species.

(Plate 2, figure 5.)

Test small with a very short triserial initial stage followed by nine pairs of short, slightly inflated chambers very faintly outlined by the very gently depressed sutures, test slightly curved and with a partial twist, oval in cross section, composed of very fine sand grains and having a quite smooth surface. One of the commoner species at no. 5 at Devils Den and no. 40 (F. A. Menken). Length .71 mm.

Genus **Eggerella** Cushman, 1933

Eggerella species B, Stelck, Wall, Bahan, and Martin.

(Plate 1, figure 5.)

Eggerella sp. B, STELCK, WALL, BAHAN, and MARTIN, 1956, Res. Council Alberta, Canada, Rep. no. 75, p. 31, pl. 4, fig. 7.

The species with which the Devils Den form is identified is from the middle Albian of western Canada. The Devils Den species is one of the rarer forms in that fauna having been found at only one station, no. 5 where only a few were found. As in many of the other arenaceous species in this fauna, the aperture is obscure. Length .30 mm.

Subfamily VERNEUILININAE Cushman, 1911

Genus **Pseudoreophax** Geroch, 1961

Pseudoreophax cisovnicensis Geroch.

(Plate 2, figure 1.)

Pseudoreophax cisovnicensis GEROCH, 1961, Polskiego Towarzystwa, Rocznik., vol. 31, pt. 1, pp. 159-167, pl. 17, text figs. 1, 2.

Where it was found this was one of the common species and while it is small it is very distinctive. The five uniserial chambers are, in general, shorter than they are broad and variable in shape and size. The test is usually curved and the chambers increase very little in diameter with growth.

The aperture is indicated by a short, pointed projection, usually well to one side of the final chamber or just off center. The test varies in cross section from round to oval and the initial end is rounded and bulbous.

It was found at stations no. 1 at the east end of Hex Hill and at no. 46 (F. A. Menken) of Devils Den, the farthest east of the samples in that locality. Length .53 mm.

Plate 1

All specimens illustrated on this plate are in the California Academy of Sciences, Department of Geology Type Collection.

FIGURE 1. *Trochammina* species. Length .84 mm.; (a) ventral view; (b) dorsal view; (c) peripheral view. Hypotype no. 12951 (CAS). From Locality 40093 (CAS), southeast side of Hex Hill, northwestern Kern County, California. Page 533.

FIGURE 2. *Glomospira gordialis* (Jones and Parker). Length .25 mm.; side view. Hypotype no. 12952 (CAS). From Locality 40092 (CAS); east side of Hex Hill, NW. Kern County, California. Page 535.

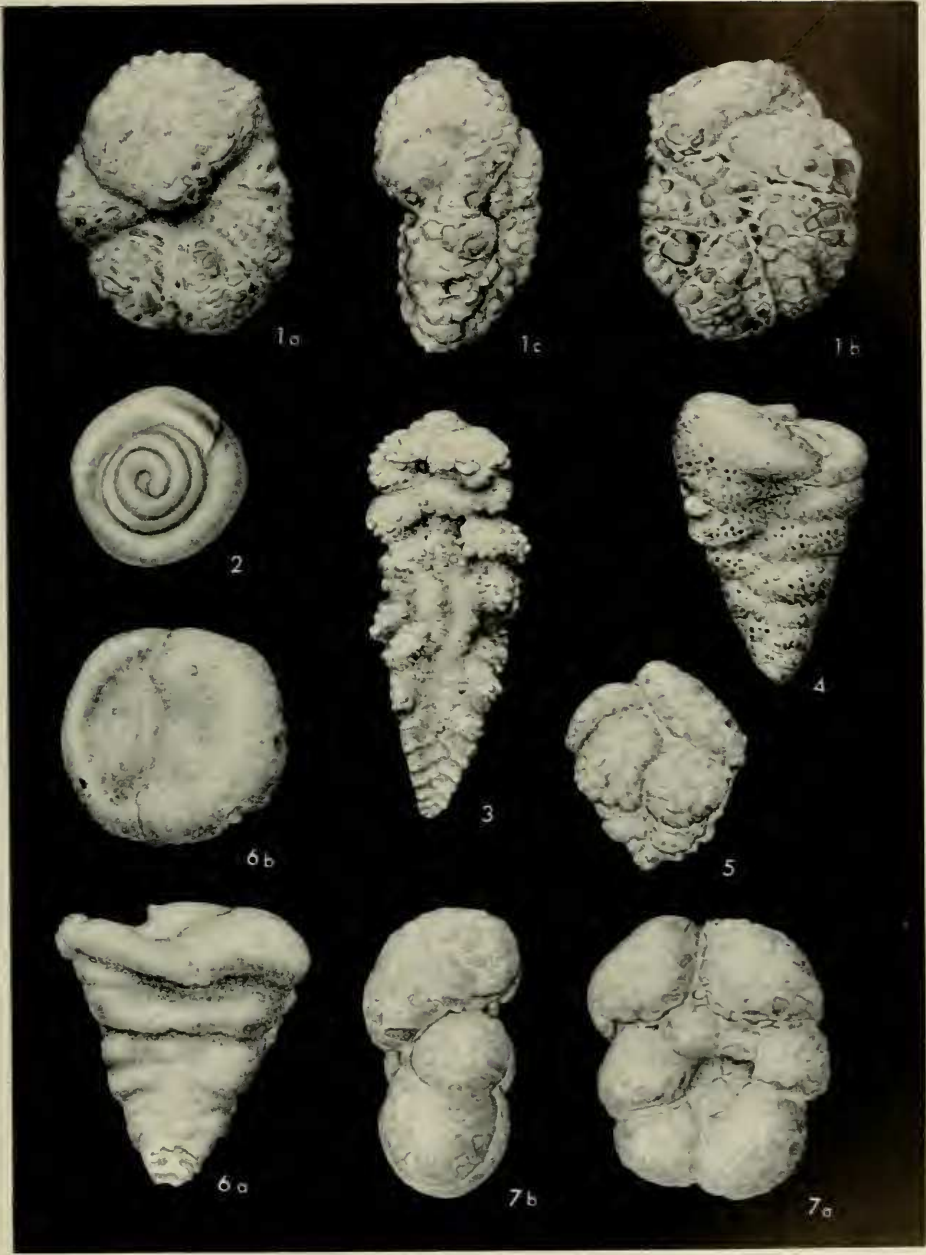
FIGURE 3. *Gaudryinella almgreni* Church, new species. Length 1.24 mm., width .59 mm.; side view. Holotype no. 12953 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 540.

FIGURE 4. *Dorothia oxycona* (Reuss). Length .92 mm.; side view. Hypotype no. 12954 (CAS). From Locality 40091 (CAS), sample 5, deep north and south gully, east side of Devils Den, NW. Kern County, California. Page 536.

FIGURE 5. *Eggerella species* B, Stelck, Wall, Bahan and Martin, Length .30 mm.; side view. Hypotype no. 12955 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 537.

FIGURE 6. *Dorothia oxycona* (Reuss). Length .49 mm.; (a) side view; (b) apertural view. Hypotype no. 12957 (CAS). From Locality 40092 (CAS), most easterly deep gully of Hex Hill, NW. Kern County, California. Page 536.

FIGURE 7. *Haplophragmoides species*. Length .53 mm.; (a) side view; (b) peripheral view. Holotype no. 12957 (CAS). From Locality 40092 (CAS), most easterly deep gully of Hex Hill, NW. Kern County, California. Page 536.



Family ASTORRHIZIDAE Brady, 1881
Subfamily HIPPOCREPININAE Rhumbler, 1895
Genus **Hyperammina** Brady, 1878

Hyperammina elongata Brady, 1878.

Hyperammina elongata BRADY, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. 1, p. 433, pl. 20, figs. 2 a, b. CUSHMAN, 1946, U. S. Geol. Surv., Prof. Pap. 206, p. 15, pl. 1, figs. 12, 13.

This long-range species occurs at stations no. 7 of Hex Creek and nos. 5 and 6 of Devils Den. From its long range it could be expected to occur in any of the samples where other arenaceous species are preserved. In its present occurrence it was not a common species.

Family TEXTULARIIDAE
Subfamily TEXTULARIINAE
Genus **Bigenerina** d'Orbigny, 1826

Bigenerina antiquissima Bartenstein and Brand.

(Plate 2, figure 4.)

Bigenerina antiquissima BARTENSTEIN and BRAND, 1951, Abh. senckenb. naturf. Ges., no. 485, p. 275, pl. 3, figs. 73, 74.

The first few chambers are irregularly biserial and twisted, short and closely set (microspheric form), with the next few chambers larger and longer and quickly becoming cuneate before the final one or two uniserial chambers. The megalospheric form is inflated and bulbous in the initial stages with the biserial stage short and less distinct, the test curved and twisted, aperture centrally located, rounded and projecting with a short neck having a rough, irregular edge. In the later chambers the degree of inflation varies so much that the tests have a knobby, twisted shape. The test is composed of a high percentage of cement and fine sand resulting in a smooth and somewhat translucent surface.

This species was found most abundant in the most northerly of the samples, near the center of the Devils Den, it is also found at stations nos. 5, 6, and no. 46 (F. A. Menken) of Devils Den, also at no. 1 at the easterly end of Hex Hill. Length .47 mm.

Bigenerina deciusi Church, new species.

(Plate 2, figure 9.)

Test finely arenaceous, biserial for the first four pairs of chambers, chambers enlarge very rapidly with growth becoming inflated and cuneate and finally uniserial in mature specimens, the uniserial part consisting of one or two chambers, test slightly twisted in early portion and curving with the change to the uniserial stage, biserial stage best developed in the microspheric form, in the megalospheric form only one or two biserial pairs of chambers can be recognized,

initial chamber blunt and rounded, aperture rounded with a ring-like neck raised very slightly above the spherical surface at the apex of the final chamber, the position remaining the same for both biserial and uniserial stages, in its early stages it is similar in appearance to *Bimonilina variana* Eicher but that species has an elongate, slit-like aperture and does not develop a uniserial stage, it also closely approximates the genus *Haeuslarella* in its cuneate chamber development but the aperture is more centrally located and mature specimens are uniserial. Length .43 mm.

HOLOTYPE no. 12966 (California Academy of Sciences, Department of Geology Type Collection), from Locality 40092 (CAS), from west slope of the most easterly deep gully on Hex Hill, about 200 feet north and 400 feet west of the center of Section 32, Township 25 south, Range 18 east, Mount Diablo base and meridian, northwest Kern County, California; C. C. Church collector; early Cretaceous.

Bigenerina deciusi was found at Locality 40092 (CAS) and Locality 40081 (CAS) in Devils Den area.

This species is named in honor of Mr. L. C. Decius, Geologist, San Francisco, California.

Subfamily VERNEULININAE

Genus *Gaudryinella* Plummer, 1931

Gaudryinella almgreni Church, new species.

(Plate 1, figure 3.)

Test finely arenaceous, triserial and triangular in the initial stage with flat to gently concave faces, biserial and compressed laterally for the next three paired chambers and finally uniserial for one or two chambers, the biserial portion may be less than three paired chambers or not apparent at all, in the uniserial stage the chambers may be irregularly rounded, triangular or quadrate and compressed with distinct downward curving lobes which project as knobs, giving the upper one-half or two-thirds of the test a knobby, irregular surface which from test to test, follows no set pattern, the uniserial stage is attained in less than half the specimens, the greater percentage reaching the somewhat cuneate, biserial second stage only with the aperture near or at the inner edge of the last chamber, whereas in the uniserial stage it is a central depression and approximately round with a slightly raised corona in some specimens. Length 1.24 mm., width, .59 mm.

HOLOTYPE no. 12953 (California Academy of Sciences, Department of Geology Type Collection), from Locality 40095 (CAS), sample no. 7 from the lower slope of a south-facing small ridge projecting into Hex Creek from the west causing it to veer to the northeast, about 1150 feet south and 200 feet east of the north quarter corner of Section 31, Township 25 south, Range 18

east, Mouth Diablo base and meridian, Hex Hill area, Kern County, California; C. C. Church collector; early Cretaceous.

The species here described differs from the original description of *Gaudryinella* in having a more compressed, distinct, biserial stage and appressed uniserial chambers which are only slightly inflated but the overall description best places it in this genus.

This species was found at station no. 15 on Hex Hill and nos. 7 and 8 on Hex Creek where it is one of the most common species.

This species is named in honor of Mr. Alvin A. Almgren of Bakersfield, California.

Superfamily NODOSARIACEA

Family NODOSARIIDAE

Subfamily NODOSARIINAE

Genus *Nodosaria* Lamarck, 1812

Nodosaria elegantia Lalicker.

(Plate 5, figures 4, 5.)

Nodosaria elegantia LALICKER, 1950, Univ. Kansas, Paleo. Contrib., art. 2, p. 15, pl. 2, figs. 9 a-d.

The above species occurs typically at stations 3, 5, and 6 at Devils Den with less typical but similar forms at stations 15 of Hex Hill and no. 7 of Hex Creek. It is usually present in small numbers.

The species was originally described from the Ellis group of Kansas of middle and late Jurassic age. It has six straight, round-bottomed, intercostate channels and six sharply keeled, straight costae extending unbroken from the rounded upper end to its bluntly pointed, apiculate initial end. The Devils Den species has a well defined spine at the initial end but this is sometimes broken off giving it the rounded appearance which Lalicker describes as characteristic of the Jurassic species. Length .55 mm., (fig. 4), .80 mm., (fig. 5).

Nodosaria humilis Roemer.

(Plate 7, figure 7.)

Nodosaria humilis ROEMER, 1841, Kreidebirges, Hannover, p. 95, pl. 15, fig. 6.

Glandulina humilis ROEMER, 1934, Eichenberg, Hauterive, p. 174, pl. 16, fig. 9; pl. 11, fig. 15.

Pseudoglandulina humilis (Roemer), BARTENSTEIN and BRAND, 1951, Abh. senckenb. naturf. Ges., no. 485, p. 315, pl. 10, figs. 266-271.

Cushman gave the new generic name *Pseudoglandulina* to this type of nodosarian previously classed as *Glandulina* to separate them from the *Glandulinas* which were derived from the Polymorphinidae. More recently, in the Treatise, Loeblich, and Tappan included the genus under *Nodosaria* which places it

Plate 2

All specimens illustrated on this plate are in the California Academy of Sciences, Department of Geology Type Collection.

FIGURE 1. *Pseudoreophax cisovnicensis* Geroch. Length .53 mm.; side view. Hypotype no. 12958 (CAS). From Locality 40092 (CAS), most easterly deep canyon of Hex Hill, NW. Kern County, California. Page 537.

FIGURE 2. *Bulbophragmium* species. Length .59 mm.; side view. Hypotype no. 12959 (CAS). From Locality 40092 (CAS), most easterly deep gully of Hex Hill, NW. Kern County, California. Page 535.

FIGURE 3. *Dorothia* cf. *D. oxycona* (Reuss) var. Length .37 mm.; (a) side view; (b) apertural view. Hypotype no. 12960 (CAS). From Locality 40091 (CAS), sample 8, deep gully, east side of Devils Den, NW. Kern County, California.

FIGURE 4. *Bigenerina antiquissima* Bartenstein and Brand. Length .47 mm.; side view. Hypotype no. 12961 (CAS). From Locality 40092 (CAS), most easterly deep gully of Hex Hill, NW. Kern County, California. Page 539.

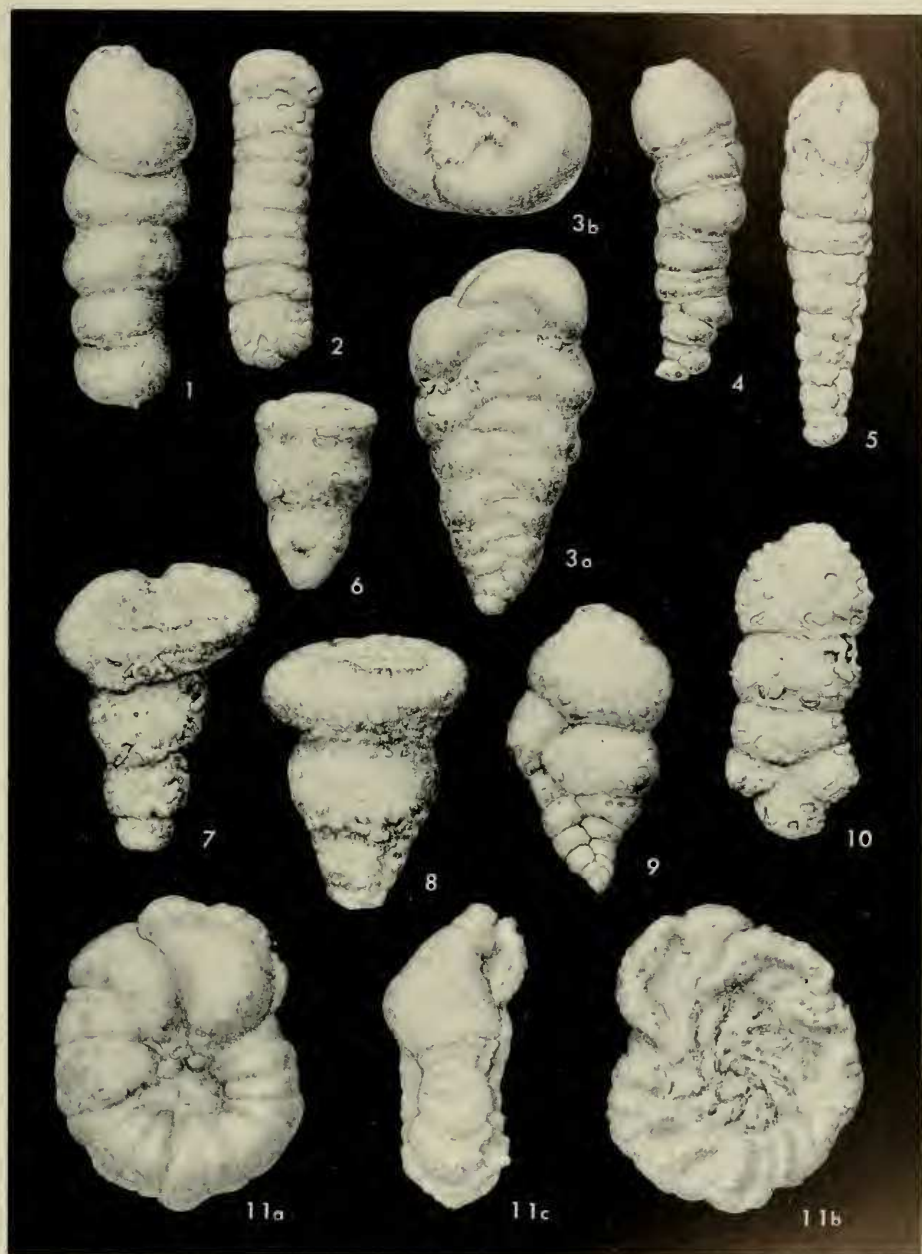
FIGURE 5. *Dorothia* species. Length .71 mm.; side view. Hypotype no. 12962 (CAS). From Locality 40091 (CAS), sample 5, deep canyon, east side of Devils Den, NW. Kern County, California. Page 537.

FIGURES 6, 7, 8. Identity unknown; side views. Hypotype nos. 12963, 12964, 12965 (CAS). Figure 6. Length .57 mm. Figure 7. Length .55 mm. Figure 8. Length .49 mm. From Locality 40091 (CAS), sample 5, deep gully east side of Devils Den, NW. Kern County, California.

FIGURE 9. *Bigenerina deciusi* Church, new species. Length .43 mm.; side view. Holotype no. 12966 (CAS). From Locality 40092 (CAS), most easterly gully of Hex Hill, NW. Kern County, California. Page 539.

FIGURE 10. *Haplophragmium aequale* (Roemer). Length .48 mm.; side view. Hypotype no. 12967 (CAS). From Locality 40092 (CAS), most easterly deep gully of Hex Hill, NW. Kern County, California. Page 536.

FIGURE 11. *Trochammina orchardensis* Church, new species. Length .59 mm., width .45 mm.; (a) ventral view; (b) dorsal view; (c) peripheral view. Holotype no. 12968 (CAS). Locality 40092 (CAS), most easterly deep gully of Hex Hill, NW. Kern County, California. Page 534.



back under its original name. It occurs rather sparingly at station no. 7 of Hex Creek. The species was listed and figured in the paper on the lower Cretaceous of Trinidad, British West Indies by Bartenstein, Bettenstaedt, and Bolli. Length .69 mm.

***Nodosaria mutabilis* (Reuss).**

Glandulina mutabilis REUSS, 1863, K. Akad. Wiss. Wien, math.-naturwiss. Cl., Sitzungsber., vol. 46, p. 58, pl. 5, figs. 7, ? 8.

Nodosaria (G.) *mutabilis* REUSS, CHAPMAN, 1893, Jour. Roy. Microsc. Soc. London, no. 4, p. 585, pl. 8, figs. 19, 20.

Pseudoglandulina mutabilis mutabilis (Reuss, 1863), BARTENSTEIN and BRAND, 1951, Abh. senckenb. naturf. Ges., no. 485, p. 315, pl. 15 C, fig. 10; pl. 14 C, fig. 36.

Only a few of this species were found at station no. 7 of Hex Creek. None were found at Devils Den. It is apparently a long range species as it occurs in the upper Cretaceous.

***Nodosaria sceptrum* Reuss.**

Nodosaria sceptrum REUSS, 1863, Hils u. Gault, p. 37, pl. 2, fig. 3. BARTENSTEIN, BETTENSTAEDT and BOLLI, 1957, Eclog. Geol. Helv., vol. 50, no. 1, p. 35, pl. 7, figs. 150 a, b.

This is one of the rarer species and was found only at Devils Den, stations nos. 1 to 5. It varies somewhat in size but retains the shape and costation typical of the species. It has been figured from the lower Cretaceous of Trinidad, British West Indies, and northwest Germany where it occurs in the Valanginian. It is very similar to *N. amphioxys* Reuss as figured by Helen Tappan from the Grayson formation of north Texas (Albian).

***Nodosaria* cf. *N. tenuicosta* Reuss.**

(Plate 6, figures 3, 5)

Nodosaria cf. *N. tenuicosta* REUSS, 1845, Verstein. bohmischen Kreide-formation. Stuttgart, Germ., E. Schweiz., Abth. 1, p. 25, pl. 13, figs. 5, 6.

The present species is almost straight-sided with very little restriction at the sutures to set the chambers apart. There are six continuous costae running the length of the test but they are low and narrow. The megalospheric form has a round proloculus with a short spine. The initial chamber is larger than the succeeding chambers. In the microspheric form the initial chambers are smaller and the additional chambers enlarge very gradually, the costae are very fine and low. The species occurs only at Devils Den at stations 5 and 6. Another form, at first thought to be a separate species, is now thought to be the microspheric form of this species. Length 1.15 mm. (fig. 3), length .92 mm. (fig. 5).

Nodosaria species.

A distinctive but rare species the first two or three chambers are small, straight-sided, and smooth, the following three or four chambers growing much larger but with no restriction at the sutures and no ornamentation. It was found at stations nos. 4 and 5 at Devils Den.

Nodosaria hexensis Church, new species.

(Plate 6, figure 13.)

Test free, multilocular, rectilinear, calcareous, composed of five ovoid chambers each slightly longer than wide, round in cross section, surface smooth, chambers enlarge gradually and regularly from the initial spheroid chamber, aperture small, round, at the end of a short, tube-like neck at the apex of the last chamber, sutures marked by a moderate restriction with a narrow welt at the juncture, chambers with moderate overlap of previous chambers, similar in general appearance to *Pseudoglandulina tenuis* (Bornemann) but with different aperture, found only at stations 5 and 6 at Devils Den. Length 1.01 mm., width .24 mm.

HOLOTYPE no. 13015 (California Academy of Sciences, Department of Geology Type Collection), from Locality 40091 (CAS), from deep north-south trending V-shaped gully beginning 500 feet south and 700 feet west of the east quarter corner of Section 20, Township 25 south, Range 18 east, Mount Diablo base and meridian, Kern County, California. Station no. 5, east bank of gully approximately 150 feet north of the mouth of the gully; C. C. Church collector; early Cretaceous.

Dentalina catenula Reuss.

Dentalina catenula REUSS, 1860, Akad. Wiss. Wien, Math.-naturwiss. Kl., Sitzungsber., vol. 40, p. 185, pl. 3, fig. 6. CUSHMAN, 1940, Contrib. Cushman Lab. Foram. Res., vol. 16, pt. 4, p. 81, pl. 13, figs. 29-34.

This is a variable and relatively common form at Hex stations nos. 7 and 8. A similar species is present at no. 4 of the Devils Den outcrop.

Dentalina communis d'Orbigny.

Dentalina communis D'ORBIGNY, 1840, Soc. Géol. France, Mém., vol. 4, p. 13, pl. 1, fig. 4. BARTENSTEIN, BETTENSTAEDT and BOLLI, 1957, Eclog. Geol. Helv., vol. 50, no. 1, p. 34, pl. 7, figs. 144, 145.

One of the more common species of the Devils Den section where it is found in samples from stations nos. 1 to 6.

Dentalina grahami Church, new species.

(Plate 3, figures 6 a, b.)

Test short, consisting of five chambers, each nearly circular in cross-section, gently arcuate, slight flattening on the inner curved side, chambers somewhat wider than high, sutures almost at right angles in the first three chambers, slightly oblique in the last two, the aperture projects as a tapered, tubular neck flush with the inner curve of the test and forms a continuous arch with the inner edge of the test, sutures slightly depressed, sides of test ornamented with a few, longitudinal, more or less discontinuous, low costae which do not extend over the last chamber, initial chamber large, globular with second chamber slightly smaller but succeeding chambers increasing in width very gently to the last chamber. Length .66 mm., width .13 mm.

HOLOTYPE no. 12974 (California Academy of Sciences, Department of Geology Type Collection), from Locality 40091 (CAS), from deep north-south trending V-shaped gully beginning 500 feet south and 700 feet west of the east quarter corner of Section 20, Township 25 south, Range 18 east, Mount Diablo base and meridian, Devils Den area, Kern County, California. Sample no. 1, east bank of gully near base, approximately 75 feet north of the mouth of the gully; C. C. Church collector; early Cretaceous.

This species was taken at stations nos. 1 and 5 in the Devils Den area, Locality 40091 (CAS).

This species is named in honor of Dr. Joseph J. Graham, Professor of Micropaleontology at Stanford University, Stanford, California.

Dentalina species.

(Plate 6, figure 2.)

Only one complete specimen of this species was found. The early chambers are compressed but the later ones are rounded in cross section and separated by a small degree of inflation and a restriction at the sutures. The entire test is marked by fine longitudinal, closely spaced costae.

Found only at the most northerly of the Devils Den canyon series which is near the center of the group of hills known as "Devils Den." Length 1.90 mm.

Genus *Vaginulina* d'Orbigny, 1826***Vaginulina recta*** Reuss.

(Plate 5, figures 1, 3.)

Vaginulina recta REUSS, 1863, Hils u. Gault, Akad. Wiss. Wien, Sitz., vol. 46, p. 48, pl. 3, figs. 14, 15.

A rather rare species at station no. 7 on Hex Creek but more common at station no. 2 in Devils Den. This is a long and narrow species which remains about the same width throughout its growth after the first globular chamber

and the one following, test straight to gently curved, chamber edges raised into a sharp ridge forming an unbroken rim on each side of the test. This is one of the more distinctive species of the fauna but it is believed to range upward into the upper part of the lower Cretaceous. Length .72 mm. (fig. 1), length .57 mm. (fig. 3).

***Vaginulina octocostata* Church, new species.**

(Plate 5, figure 2; plate 6, figure 6.)

Test free, calcareous, rectilinear, gently curved, compressed ovate in section, surface marked by eight vertical, more or less continuous costae two of which are at the outer edges of the test and three equally spaced on each side, all irregularly carinate and extending from the initial end to the edge of the final chamber where they merge around the apertural face, often forming a slight depression and extending to the aperture at the peripheral angle making it more apiculate, chambers enlarge very gradually for the first two or three then continue with little change for the final two or three chambers which are usually five or six in number, initial chamber small and pointed with a short basal spine in the microspheric form and compressed spherical in the megalospheric form, additional chambers compressed to gently inflated and defined by gentle depressions at the sutures. In the more extreme developments, as in figure 6, plate 6, the species has a more rounded final chamber and more restricted suture as in *Dentalina*. Without the intermediate forms one might easily identify the two extremes as different species or genera. Length .86 mm.

HOLOTYPE no. 13009 (California Academy of Sciences, Department of Geology Type Collection), from Locality 40091 (CAS), from deep north-south trending V-shaped gully beginning 500 feet south and 700 feet west of the east quarter corner of Section 20, Township 25 south, Range 18 east, Mount Diablo base and meridian, Kern County, California. Sample from station no. 8, from steep east bank of gully about 20 feet south of junction with first northeast trending branch; this is about 600 feet due west of the east quarter corner of Section 20, Sawtooth Ridge quadrangle, 1953 edition; C. C. Church collector; early Cretaceous.

This species was found at stations 5 and 8 at Locality 40091 (CAS), Devils Den area.

***Vaginulina debilis* (Berthelin).**

(Plate 6, figure 4.)

Marginulina debilis BERTHELIN, 1880, Soc. Géol. France, Mém., ser. 3, vol. 1, Mem. 5, p. 35, pl. 3, (26) fig. 28.

Vaginulina debilis (Berthelin), TAPPAN, 1940, Jour. Paleo., vol. 14, no. 2, p. 108, pl. 16, figs. 26 a, b.

The original description is of a smooth form but a similar species from the Grayson formation has both smooth and sparsely costate types. The ones with the costation are very similar to those from the more northerly of the Devils Den samples but smooth forms are present here also. A similar form without the early chambers was figured by Bartenstein, Bettenstaedt and Bolli from the lower Cretaceous of Trinidad. In this instance it was classified as "*Dentalina*" *debilis* (Berthelin). The Trinidad species appears to be more sharply angled and flatter on the side. It is also without any vertical costae. Some of the more attenuated and less angled fragments from Devils Den could very readily be considered as *Dentalina* but where perfect specimens were found, the test was wedge-shaped and compressed. Found only at Devils Den. Length 1.64 mm.

***Vaginulina striolata* Reuss.**

(Plate 4, figure 9; plate 6, figure 14).

Vaginulina striolata REUSS, 1863, Akad. Wiss. Wien, Sitz., vol. 46, pt. 1, p. 46, pl. 3, fig. 7.

Vaginulina kochii var. *striolata* CUSHMAN and ALEXANDER, 1930, Cushman Lab. Foram. Res., Contr., vol. 6, pt. 1, p. 4, pl. 1, figs. 10-16.

Vaginulina striolata Reuss, 1863, BARTENSTEIN and BRAND, 1951, Abh. senckenb. naturf., Ges., no. 485, p. 294, pl. 6, figs. 161-164.

This may be a variety of *Vaginulina kochii* as it was considered by Cushman and Alexander and by Helen Tappan. It is a rather rare species here but was found at Stations 5 and 6 of Devils Den and at no. 7 of Hex Creek. Length 1.06 mm. (pl. 4, fig. 9). Length 1.07 mm. (pl. 6, fig. 14).

***Vaginulina kochii* Roemer.**

(Plate 4, figure 11.)

Vaginulina kochii ROEMER, 1840-1841, Verst. norddeutsch. Kreide, p. 96, pl. 15, fig. 10.

TAPPAN, HELEN, 1940, Jour. Paleo., vol. 14, no. 2, p. 109, pl. 17, figs. 2-4.

This is one of the more commonly occurring species at both Hex Creek and Devils Den but it is not abundant in any of the samples. It is listed from the lower Cretaceous of Europe, the lower Cretaceous of Trinidad, southeastern United States and the upper Cretaceous of the Sacramento Valley, California. Length .96 mm.

***Vaginulina riedeli riedeli* Bartenstein and Brand.**

(Plate 4, figures 7, 8.)

Vaginulina riedeli riedeli BARTENSTEIN and BRAND, 1951, Abh. senckenb. naturf. Ges., no. 485, p. 295, pl. 7, figs. 165 a, b, c.

One of the less common but very distinctive species of the Hex Hill fauna. Found at station no. 15, Hex Hill. Length 1.11 mm. (fig. 7), length 1.00 mm. (fig. 8).

Vaginulina truncata Reuss.

Vaginulina truncata REUSS, 1863, Hils u. Gault, p. 47, pl. 3, fig. 9. BARTENSTEIN and BRAND, 1951, Abh. senckenb. naturf. Ges., no. 485, p. 293, pl. 12B.

This rare variety may be only a more flaring variation of *V. kochii* as similar species have been described as *V. kochii* from the German lower Cretaceous by Bartenstein and Brand. Found at stations no. 5 and no. 8 of Devils Den.

Genus Vaginulinopsis Silvestri, 1904**Vaginulinopsis pachynota** Ten Dam.

(Plate 4, figure 3.)

Vaginulinopsis pachynota TEN DAM, 1946, Jour. Paleo., vol. 20, no. 6, p. 575, pl. 88, figs. 5, 6 a, b.

A common and variable form at stations nos. 5 and 6 of Devils Den but not found in the Hex Hill samples. This strongly sutured species is similar in many respects to some of the later Eocene forms. Length 1.20 mm.

Genus Marginulina d'Orbigny, 1826**Marginulina bullata** Reuss.

Marginulina bullata REUSS, 1845, Verstein. böhm. Kreideformation, pt. 1, p. 29, pl. 13, figs. 34-38. CUSHMAN, 1937, Cushman Lab. Foram. Res., Contrib., vol. 13, p. 96, pl. 14, figs. 9-15. CUSHMAN, 1944, Cushman Lab. Foram. Res. Contrib., vol. 20, p. 6, pl. 1, fig. 21.

This species occurs very sparingly in samples nos. 7 and 8 of Hex Creek. Very similar species are, *M. curvatura* Cushman and *M. texasensis* Cushman, both from the upper Cretaceous of Texas.

Marginulina cf. M. parkeri (Reuss).

(Plate 3, figure 3.)

Lenticulina parkeri REUSS, 1863, Hils u. Gault, p. 59, pl. 5, fig. 14.

Lenticulina (Marginulinopsis) parkeri (Reuss), BARTENSTEIN and BRAND, 1951, Abh. senckenb. naturf. Ges., no. 485, p. 288, pl. 6, figs. 136, 137.

This appears, from the figures, to be a much smoother form than the species to which it is compared. The test is without ornamentation and the sutures flush with the surface although very distinctly outlined. Even the initial chambers are clearly displayed showing the half coiled nature of the early chambers which gives to the early portion of the test its distinct but gentle curve. Following the first two or three chambers the oval section continues its growth without appreciable change with parallel, oblique sutures outlining the chambers which are wider than they are high, the test itself gently curved or almost straight with smooth, parallel sides. Length 1.74 mm.

Marginulina robusta Reuss.

(Plate 4, figure 6.)

Marginulina robusta REUSS, 1863, Hils u. Gault, p. 63, pl. 6, figs. 5, 6.*Lenticulina (Marginulinopsis) robusta* (Reuss), 1863, BARTENSTEIN and BRAND, 1951, Abh. senckenb. naturf. Ges., no. 485, p. 289, pl. 6, figs. 142, 143.*Marginulina robusta* (Reuss), TEN DAM 1948, Neocom., Jour. Paleo., vol. 22, no. 2, p. 185, pl. 32, fig. 6.

This species was found sparingly at stations nos. 1, 4, and 5 of Devils Den area but not at Hex Creek or Hex Hill. From a comparison with figures and actual specimens from the European section, it appears to be very close to the species described by Reuss. Length .67 mm.

Marginulina pyramidalis Koch.

(Plate 6, figure 12.)

Nodosaria pyramidalis KOCH, 1851, Palaeontographical, p. 169, pl. 24, fig. 8.*Marginulina pyramidalis* (Koch), BARTENSTEIN and BRAND, 1951, Abh. senckenb. naturf. Ges., no. 485, p. 307, pl. 9, figs. 221-223.

A common species at station 5 of Devils Den and found from nos. 2 to 6. It is quite variable in size but retains its characteristics of strong, continuous carinate costae and initial spine and prominent, off-center, spout-like aperture, final chamber noticeably larger and more inflated, initial chamber also somewhat larger and more bulbous than those immediately following. It is one of the distinctive species of the Devils Den section but not found in the Hex Hill area. Length 1.09 mm.

Marginulina sigali Bartenstein, Bettenstaedt, and Bolli.

(Plate 6, figure 8.)

Lenticulina (Marginulina) sigali BARTENSTEIN, BETTENSTAEDT and BOLLI, 1957, Eclog. Geol. Helv., vol. 50, no. 1, p. 32, pl. 5, fig. 99; pl. 6, figs. 130, 131 a, b.

This is a quite common species at station 5 of Devils Den but was not found in other parts of the section or at Hex Hill. It is a species with distinctive features and appears from Bartenstein, Bettenstaedt, and Bolli, plate 5, figure 99 (see above) to be the same as their Trinidad species. Length .61 mm.

Marginulina species.

(Plate 4, figure 12.)

This is one of the rarer species of the Hex formation. It was found only at stations no. 7 of Hex Creek and no. 5 of Devils Den but most likely will be found

Plate 3

All specimens illustrated on this plate are in the California Academy of Sciences, Department of Geology Type Collection.

FIGURE 1. *Lingulina tenera* Bornemann. Length .59 mm.; side view. Hypotype no. 12969 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully east side of Devils Den, NW. Kern County, California. Page 560.

FIGURE 2. *Saracenaria spinosa* (Eichenberg). Length .94 mm.; side view. Hypotype no. 12970 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 552.

FIGURE 3. *Marginulina* cf. *M. parkeri* (Reuss). Length 1.74 mm.; side view. Hypotype no. 12971 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 548.

FIGURE 4. *Citharina* species. Length 1.12 mm.; side view. Hypotype no. 12972 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 557.

FIGURE 5. *Citharina acuminata* (Reuss). Length 1.27 mm.; side view. Hypotype no. 12973 (CAS). From Locality 40091 (CAS), sample 5, from deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 556.

FIGURE 6. *Dentalina grahami* Church, new species. Length .66 mm.; width .13 mm. (a) side view; (b) side view. Holotype no. 12974 (CAS). From Locality 40091 (CAS), sample 5, from deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 545.

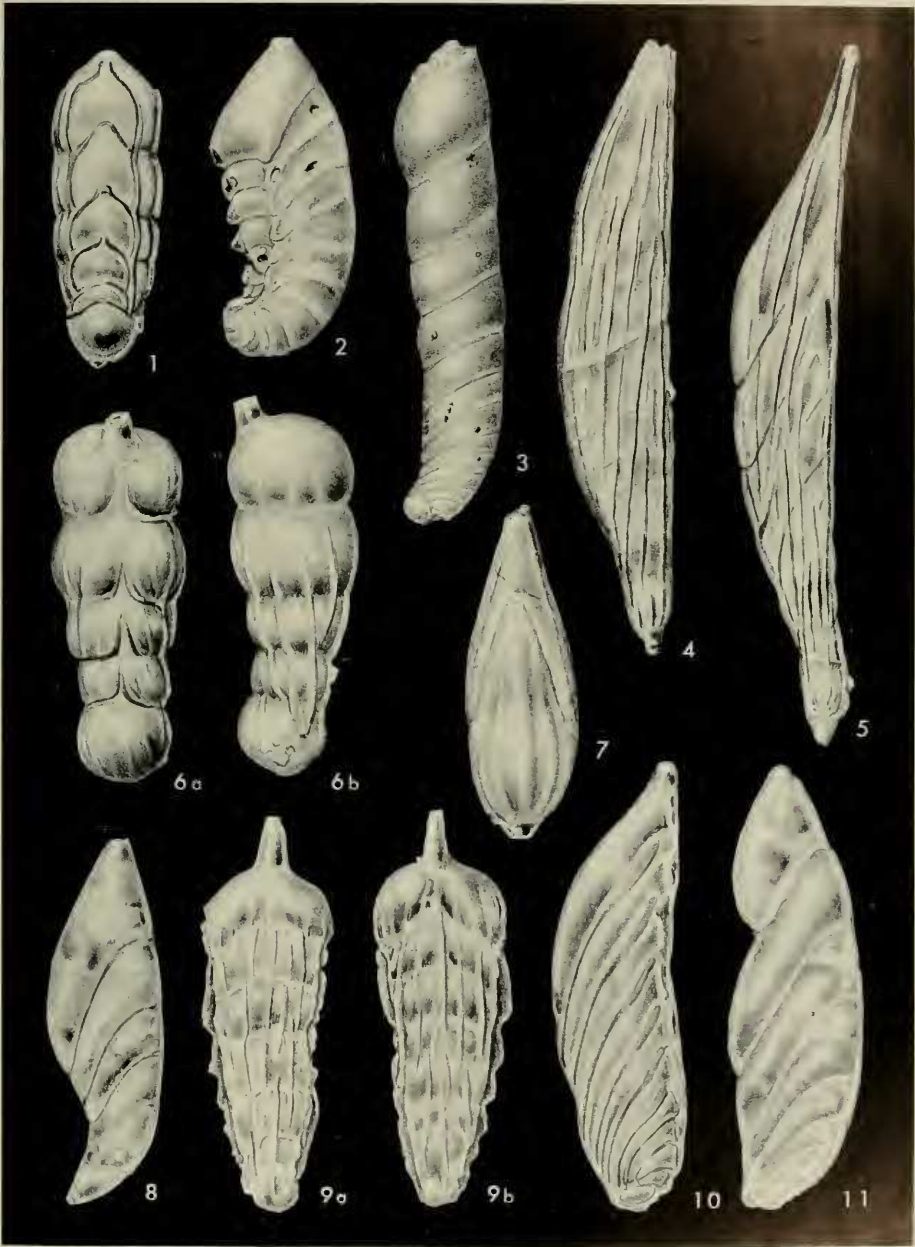
FIGURE 7. *Fronicularia franki* Cushman. Length 1.21 mm.; side view. Hypotype no. 12975 (CAS). An immature specimen from Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 557.

FIGURE 8. *Astaculus perobliqua* (Reuss). Length .82 mm.; side view. Hypotype no. 12976 (CAS). From Locality 40091 (CAS), sample 6, deep gully, east side of Devils Den, NW. Kern County, California. Page 556.

FIGURE 9. *Menkenina berryi* Church, new species. Length 1.17 mm.; width .37 mm.; (a) dorsal view; (b) ventral view. Holotype no. 12977 (CAS). From Locality 40091 (CAS), sample 6, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 561.

FIGURE 10. *Citharina* species "3," (Bartenstein and Brand). Length .83 mm.; side view. Hypotype no. 12978 (CAS). From Localities 27501 (CAS), 47 (FAM). Near central area of Devils Den, NW. Kern County, California. Page 556.

FIGURE 11. *Astaculus perobliqua* (Reuss). Length 1.65 mm.; side view. Hypotype no. 12979 (CAS). From Locality 40091 (CAS), sample 6, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 556.



elsewhere in the section. It is almost round in section and with parallel sides and only a suggestion of a beginning coil, chambers few, usually not more than six which indicates the nature of the short, thick species, surface smooth and only slightly indented at the last suture, sutures flush with surface, almost at right angles to dorsal side in later chambers, aperture at dorsal angle of last chamber. Length 1.03 mm.

Genus *Marginulinopsis* Silvestri, 1904

Marginulinopsis gracillissima (Reuss).

(Plate 6, figure 9.)

Cristellaria gracillissima REUSS, 1862, Sitz. Ber. Akad. Wiss. Wien, vol. 46, p. 64, pl. 6, figs. 9, 10.

Marginulinopsis gracillissima (Reuss), TEN DAM, 1948, Jour. Paleo., vol. 22, no. 2, p. 184, pl. 32, figs. 7, 8.

This species was found sparingly but consistently through most of the Devils Den series from 1 to 8. Most specimens do not have the pronounced initial coil as figured in the original type, but in all other respects is very similar. In some of the smaller varieties the aperture is drawn out into a distinct neck. Length .49 mm.

Marginulinopsis collinsi Mellon and Wall.

Marginulinopsis collinsi MELLON and WALL, 1956, Res. Council Alberta, Report no. 72, pt. 1, p. 20, pl. 2, figs. 1, 2.

There is a tendency for this species, from the Hex Creek occurrence, to develop the flattened apertural face of a *Saracenaria* reminiscent of *Lenticulina valanginiana* Bartenstein and Brand of the lower Cretaceous of Germany. Our Hex Creek, no. 7 occurrence is quite rare but it is possible that it may be less so with further sampling. The species named by Mellon and Wall from Alberta, Canada, is from the basal Clearwater formation, considered to be of middle Albian in age on the basis of its ammonite fauna. A few specimens were also found at station no. 48 (F. A. Menken) of Devils Den which are very similar to the species described by Mellon and Wall.

Marginulinopsis species.

(Plate 4, figure 13.)

This species is similar in general shape and degree of uncoiling to *Cristellaria hamata* Franke which was described from the Oligocene of Denmark but has fewer and wider chambers and greater inflation in the final chamber. It is one of the more common species found in samples from stations 7 and 8 of Hex Creek, Locality 40095 (CAS) but was not found in the Devils Den samples. Length 1.03 mm.

Genus *Saracenaria* Defrance in de Blainville, 1824*Saracenaria italica* Defrance.

(Plate 4, figure 5.)

Saracenaria italica DEFANCE, 1824, Tableau, p. 176 (vol. 32), pl. 13, fig. 6 (vol. 12).
CHAPMAN, 1894, Jour. Roy. Micr. Soc. London, no. 7, p. 653, pl. 10, fig. 10.

This is not one of the commoner species but it was found at station no. 7 of Hex Creek and later more commonly at nos. 2 and 5 of Devils Den. It is a large robust form. Length .78 mm.

Saracenaria spinosa Eichenberg, 1935.

(Plate 3, figure 2.)

Saracenaria spinosa EICHENBERG, 1935, Niedersächs. Geol. Ver., Jahresberichts 27 (Mitt. Roemer-Museum, Hildesheim, no. 37, Teil 1, Folge 4), p. 10, pl. 4, fig. 5 a-d. Aptian, Germany. TAPPAN, HELEN, 1962, U. S. Geol. Surv., Prof. Paper 236C, p. 165, pl. 41, figs. 18, 19.

Occurs rather sparingly at station no. 7 of Hex Creek and at station no. 4 of Devils Den. It is much more slender and elongate than *S. italica* and a sharp spine terminates the base of the chambers at the two side angles where the face and lateral sutures meet. Specimens from the Aptian of northern Germany are very similar to the Hex Hill specimens. The species figured from Alaska is shorter and less spinose. Length .94 mm.

Genus *Lenticulina* Lamarck, 1804*Lenticulina saxonica saxonica* Bartenstein and Brand.

(Plate 5, figures 11 a, b.)

Lenticulina saxonica saxonica BARTENSTEIN and BRAND, 1951, Abh. senckenb. naturf. Ges., no. 485, p. 284, pl. 5, figs. 115 a, b.

This is one of the common forms at stations nos. 7 and 8 of Hex Creek. It is usually very well preserved as it is large and has a sturdy test. Length 1.29 mm.

Lenticulina (Lenticulina) münsteri (Roemer).

(Plate 5, figures 7 a, b.)

Robulina münsteri ROEMER, 1839, Oolith.-Geb., p. 48, pl. 20, fig. 29.

Lenticulina (Lenticulina) münsteri (Roemer), BARTENSTEIN and BRAND, 1951. Abh. senckenb. naturf. Ges., no. 485, p. 283, pl. 5, fig. 109.

This is one of the largest and most common of the many species of *Lenticulina* at stations nos. 7 and 8 of Hex Creek. It varies somewhat in the raised or depressed condition of the suture but in general it is a quite smooth form with

seven to nine chambers, sutures curved, slight depression at the center due to the overlapping of the last few chambers and concealing a possible umbo, outer periphery rather sharply keeled and uniform. Length 1.34 mm.

Lenticulina species.

(Plate 4, figure 2.)

A few specimens of this unidentified species were found at station no. 7 of Hex Creek. It has seven to nine chambers with prominent, sharp raised sutures which becomes less prominent toward the periphery, each one gently curved, periphery sharply keeled with a thin carina of clear shell material, raised sutures may end abruptly near center without coalescing or blend with the others to form a slightly higher center, height of test from .8 to 1 mm.; width .5 mm. Length .96 mm.

Lenticulina species.

(Plate 4, figure 1.)

This large, heavily ornamented species is one of the less common of the large lenticulinas at stations nos. 5 and 6 of Devils Den. From among the many at this point the present species may be distinguished by the presence of faint to prominent spiral ridges which generally follow the outer curve of the test, often being higher and noded over the sutures and strongest near the umbonal area, sutures may be raised into welts near the center but usually are flush or depressed near the periphery. In the specimen illustrated the curved welts are strongest between sutures and more regular and prominent than usual. Test large, calcareous, free, thick, lenticular, often reaching a diameter of 1.5 mm. with a height only slightly greater than the width, periphery strongly keeled throughout, surface generally uneven, chambers six to eight in final whorl, sutures gently curved, aperture typically radial. In rare instances the final chamber may depart from the curve and extend out from the test in a straight line resembling a blunt spine in the final chamber. This may be an aberrant form.

The variability of the species suggests that it may be a variation of one of the large species with which it is associated but the smaller number of chambers, the strong peripheral flange and the rugose surface of the test sets it apart. Length 1.46 mm.

Lenticulina kugleri Bartenstein, Bettenstaedt, and Bolli.

Lenticulina kugleri BARTENSTEIN, BETTENSTAEDT, and BOLLI, 1957, Eclog. Geol. Helv., vol. 50, no. 1, p. 27, pl. 5, fig. 95; pl. 6, figs. 116 a, b.

This species was found only at station no. 47 (F. A. Menken) where it



FIGURE 2. *Lenticulina eichenbergi* Bartenstein and Brand. Hypotype no. 12950 (Calif. Acad. Sci., Dept. Geol. Type Coll.), from the same locality as the specimen shown in figure 3.

FIGURE 3. *Lenticulina* cf. *L. eichenbergi* Bartenstein and Brand. Hypotype no. 12949 (Calif. Acad. Sci., Dept. Geol. Type Coll.), from Locality 27502 (CAS), no. 50, about 600 feet west and 100 feet north of the center of Section 20, Township 25 south, Range 18 east, Mount Diablo base and meridian, Kern County, California.

was not a rare species. It is a compressed species with the sutures thickened and raised and the test longer than broad.

***Lenticulina* (L.) *eichenbergi* Bartenstein and Brand.**

(Figure 2.)

Lenticulina (*Lenticulina*) *eichenbergi* BARTENSTEIN and BRAND, 1951, Abh. senckenb. naturf. Ges., no. 485, p. 285, pl. 5, figs. 118, 119.

In the earlier samples from Devils Den this species was found at stations nos. 46 and 50 (F. A. Menken) and later from 5 to 8 of the Devils Den series. Also at Locality 27605 (CAS), south slope of Hex Hill. It is a large, well-preserved form with considerable variation in the number and arrangement of nodes or bosses in the central area and along the curved sutures where they may at times coalesce to form a welt, both nodes and broken sutures diminish toward the periphery, usually leaving a smooth outer edge, periphery sharply keeled to carinate, number of chambers in outer whorl, seven to ten, average height 1 mm., width .8 mm, length 1.02 mm.

***Lenticulina* cf. *L. eichenbergi* Bartenstein and Brand.**

(Figure 3.)

Of the several species of large lenticulinas of the Devils Den 40091 (CAS), station 5 locality, this one is probably a variety of *L. eichenbergi* Bartenstein and Brand, but in the character of its ornamentation it also has much in

common with a species described by Bartenstein, Bettenstaedt, and Bolli from the lower Cretaceous of Trinidad, British West Indies as *L. ouachensis* (Sigal, 1952). These authors also described three subspecies of *L. ouachensis*, suggesting a proliferation of varieties of the species at this time or possibly a wide variation in a single species. Regardless of the true or accepted nature of the species, a similar wide variation is evident among the Devils Den specimens. The species and its variations are well represented at station 5 at Localities 40091 and 27502 (CAS), station no. 50 (F. A. Menken) both from Devils Den. Length .88 mm.

Genus *Darbyella* Howe and Wallace, 1932

Darbyella species.

(Plate 7, figures 10 a, b, c.)

A species from the Jackson Eocene described by Howe and Wallace is very similar to the lower Cretaceous species except that, in perfect specimens, the Devils Den species has a typical conical, radiate aperture. The Eocene species has a slit-like aperture with a calcareous lip on either side.

The authors of the Treatise consider *Darbyella* as an aberrant form of *Lenticulina* but it is so distinct and constant in its characters that its occurrence here seems worthy of mention. It was found at stations nos. 4 and 5 of Devils Den. Length .69 mm.

Genus *Astacolus* de Montfort, 1808

Astacolus grata (Reuss).

(Plate 4, figure 10.)

Cristellaria grata REUSS, 1862, Sitz. Akad. Wiss. Wien, vol. 46, pt. 1, p. 70, pl. 7, figs. 14 a, b.

CUSHMAN, 1926, Bull. Amer. Assoc. Petr. Geol., vol. 10, p. 598, pl. 19, figs. 1 a, b.

Marginulina grata (Reuss), CUSHMAN and JARVIS, 1932, Proc. U. S. Nat. Mus., no. 2914, vol. 80, art. 14, p. 25, pl. 7, figs. 7 a, b; pl. 8, figs. 3 a, b.

This is a very smooth form but the sutures are very distinct as fine lines. The present species differs slightly from the figured specimen of Cushman and Jarvis in that the last few chambers do not tend to extend down to the initial coil but strike across at a more gentle angle. It is quite common at stations nos. 7 and 8 of Hex Creek. Length 1.36 mm.

Astacolus incurvata (Reuss).

Cristellaria incurvata REUSS, 1863, K. Akad. Wiss. Wien, p. 66, pl. 6, fig. 18.

Lenticulina (Astacolus) incurvata (Reuss), BARTENSTEIN, BETTENSTAEDT, and BOLLI, 1957, Ecol. Geol. Helv., vol. 50, no. 1, p. 30, pl. 3, figs. 57 a, b; pl. 4, fig. 86.

This species occurs at stations no. 7 of Hex Creek and no. 15 of Hex Hill, also at no. 3 of Devils Den. The species is very similar to other uncoiled,

elongate species in these faunas and it is often a question of whether there are a number of species or if they are variants of a single species.

***Astacolus perobliqua* (Reuss).**

(Plate 3, figures 8, 11.)

Cristellaria (*Cristellaria*) *perobliqua* REUSS, 1863, K. Akad. Wiss. Wien, Math., Naturw. Cl., Sitzungsber., vol. 46, pt. 1, p. 67, pl. 7, fig. 3.

There is considerable variation in this species, especially in the initial chambers which may form a sharply curved, pointed, primary part or start with a gentle, rounded curve which emerges quickly into a larger slightly curved but generally parallel sided test with highly oblique sutures and more inflated, slightly wedge-shaped chambers in section, usually seven chambers.

Fairly common at station no. 6 of Devils Den but found also at nos. 4 and 5 of the same section. Length .82 mm. Another specimen (figure 11) was found at station 6 which had a length of 1.65 mm.

Genus *Citharina* d'Orbigny in de la Sagra, 1839

***Citharina acuminata* (Reuss).**

(Plate 3, figure 5.)

Vaginulina acuminata REUSS, 1863, K. Akad. Wiss. Wien, Math.-Naturw. Cl., Sitzungsber., vol. 46, pt. 1, p. 49, pl. 4, fig. 1.

Citharina acuminata (Reuss), BARTENSTEIN, BETTENSTAEDT and BOLLI, 1957, Eclog. Geol. Helv., vol. 50, no. 1, p. 39, pl. 7, figs. 159 a, b.

One of the rarer species at Devils Den, it was found only at stations nos. 1 and 5. It was not found in the Hex Hill area. Length 1.27 mm.

***Citharina* species "3," (Bartenstein and Brand).**

(Plate 3, figure 10.)

Vaginulina sp. 3, BARTENSTEIN and BRAND, 1951, Abh. senckenb. naturf. Ges., no. 485, p. 292, pl. 6, fig. 153.

There is considerable variation in this species which corresponds very closely to the species figured by Bartenstein and Brand. It occurs rather commonly at the most northerly of the Devils Den series of samples and F. A. Menke no. 47 and is scarce but present at station no. 8 of Hex Creek. What appears to be a closely related species occurs at station no. 7 on Hex Creek. Length .83 mm.

***Citharina kernensis* Church, new species.**

(Plate 4, figure 4.)

Test small, calcareous, compressed, wedge-shaped in cross section, more compressed in early chambers, becoming slightly inflated in later ones, early

chambers develop a sharp curve, later ones become more oblique and terminate in a more or less straight line at the back, later chambers tend to overlap the previous chambers, extending down almost to the curved initial part of the chambers, aperture a small opening at the apex of the final chamber where the somewhat angular suture and the sharply angled back side of the test converge to form a slight neck for the aperture, sutures of clear shell material may be depressed or raised in a definite welt, in some specimens forming a sharp edge to the more inflated part of the chambers. This species is definitely narrower than *Citharina* species 3 and more inflated but the wide variation in both species and their general similarities suggests the possibility that they are a single species. If further work and more detailed comparisons of the species should support the above possibility, it is this authors suggestion that the name *C. kernensis* be retained as the name for both variations. Length .52 mm., width .15 mm.

HOLOTYPE no. 12983 (California Academy of Sciences, Department of Geology Type Collection), from Locality 40095 (CAS), sample no. 7, from the lower slope of a south-facing small ridge projecting into Hex Creek from the west causing it to veer to the northeast, about 1150 feet south and 200 feet east of the north quarter corner of Section 31, Township 25 south, Range 18 east, Mount Diablo base and meridian; C. C. Church collector; early Cretaceous.

***Citharina* species.**

(Plate 3, figure 4.)

This very small species may be a variation of *C. acuminata* but it is much narrower and the oblique costae are fewer and less continuous than those in *C. acuminata*. It is very similar in shape and markings to the much larger species from the Duck Creek, lower Cretaceous of Texas, which was referred to as *Vaginulina raristriata* (Chapman) by Helen Tappan in her paper on the foraminifera of that formation. It is rare in the Devils Den samples having been found only at stations nos. 1 and 5. It probably occurs at other points in the section but its relatively small size and delicate construction renders it more difficult to detect and less likely to be found whole. Length 1.12 mm.

Genus *Frondicularia* Defrance in d'Orbigny, 1826

***Frondicularia frankei* Cushman.**

(Plate 3, figure 7; plate 6, figures 1, 10.)

Frondicularia angusta REUSS, 1860, Akad. Wiss. Wien. Math.-naturwiss. Kl., Sitzungsber., vol. 40, p. 196, pl. 4, fig. 5.

Frondicularia frankei CUSHMAN, 1936, Contrib. Cushman Lab. Foram. Res., vol. 12, pt. 1, p. 18, pl. 4, figs. 6, 7.

Found only at Devils Den in samples from stations nos. 2 to 6. In all of

Plate 4

All specimens illustrated on this plate are in the California Academy of Sciences, Department of Geology Type Collection.

FIGURE 1. *Lenticulina* species. Length 1.46 mm.; side view. Hypotype no. 12980 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 553.

FIGURE 2. *Lenticulina* species. Length .96 mm.; side view. Hypotype no. 12981 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 553.

FIGURE 3. *Vaginulinopsis pachynota* Ten Dam. Length 1.20 mm.; side view. Hypotype no. 12982 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 548.

FIGURE 4. *Citharina kernensis* Church, new species. Length .52 mm.; width .15 mm.; side view. Holotype no. 12983 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 556.

FIGURE 5. *Saracenaria italica* Defrance. Length .78 mm.; side view. Hypotype no. 12984 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 552.

FIGURE 6. *Marginulina robusta* Reuss. Length .67 mm.; side view. Hypotype no. 12985 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 549.

FIGURE 7. *Vaginulina riedeli riedeli* Bartenstein and Brand. Length 1.11 mm.; side view. Hypotype no. 12986 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 547.

FIGURE 8. *Vaginulina riedeli riedeli* Bartenstein and Brand. Length 1.00 mm.; side view. Hypotype no. 12987 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 547.

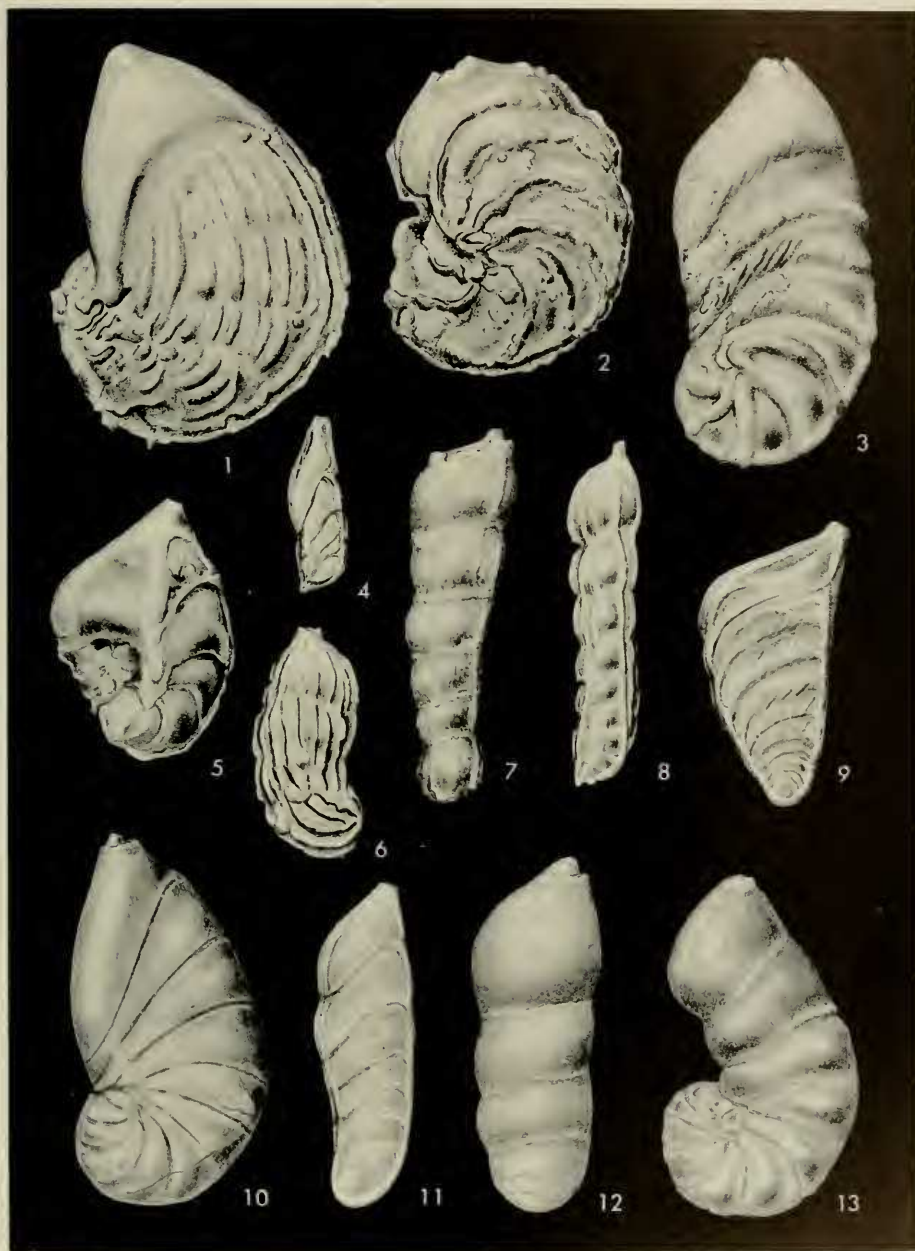
FIGURE 9. *Vaginulina striolata* Reuss. Length 1.06 mm.; side view. Hypotype no. 12988 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 547.

FIGURE 10. *Astacolus grata* (Reuss). Length 1.36 mm.; side view. Hypotype no. 12989 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 555.

FIGURE 11. *Vaginulina kochii* Roemer. Length .96 mm.; side view. Hypotype no. 12990 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 547.

FIGURE 12. *Marginulina* species. Length 1.03 mm.; side view. Hypotype no. 12991 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 549.

FIGURE 13. *Marginulinopsis* species. Length 1.03 mm.; side view. Hypotype no. 12992 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 551.



its occurrences it was found sparingly and usually broken. Length 1.21 mm. (pl. 3, fig. 7), length 3.19 mm. (pl. 6, fig. 1). [Specimen illustrated in pl. 6, fig. 10 missing.]

***Frondicularia concinna* Koch.**

Frondicularia concinna KOCH, 1851, Palaeontographica, 1, p. 169, Cassel. REUSS, 1863, Sitz. Akad. Wiss. Wien, p. 54, pl. 4, fig. 13. HECHT, 1938, Abh. senckenb. naturf. Ges. 443, p. 28 (as *Frondicularia* D.6), pl. 18b, figs. 116-119.

This is a very distinctive species but also very rare as only two imperfect specimens were found. One of these has only the first few initial chambers missing. It was found at station no. 5 of Devils Den.

***Frondicularia* species.**

(Plate 5, figure 10.)

Frondicularia sp. 2, 1957, BARTENSTEIN, BETTENSTAEDT and BOLLI, Eclog. Geol. Helv., vol. 50, no. 1, p. 40, pl. 5, fig. 109; pl. 6, figs. 138 a, b.

This species, from stations 7 and 8 of Hex Creek, is so similar to the species from the lower Cretaceous of Trinidad referred to above, that I have used their names and number. Faint vertical costae are visible on some specimens. It is a large, robust species, some specimens measuring over 1 mm. in length. In the earlier half of the test the edge is flattened and forms a distinct right angle with the two faces. Length 1.22 mm.

***Frondicularia* species.**

This species is similar in some respects to *Frondicularia* species 2 and may be a variation of that species. It differs in being flatter and without inflation of the chambers. Also in many of the specimens the first few chambers are uniserial. The test as a whole is quite compressed and thin and the edges at right angles to the sides, the test itself of medium size and the chevron-shaped chambers have a moderate flair.

***Frondicularia* species.**

(Plate 5, figure 6.)

A very rare species, only two specimens were found and the second one is probably immature. This species is almost parallel sided as it tapers very gently with the addition of each chamber, the cross section is a flattened oval and the edges taper to a thin, narrow carina, the final chamber is attenuated and the aperture at the end of a rather long, narrow neck, the initial chamber

is blunt and rounded and compressed into a flat oval which changes little with growth, surface marked by faint, broken costae. Length .73 mm.

Subfamily LINGULININAE Loeblich and Tappan, 1961

Genus *Lingulina* d'Orbigny, 1826

Lingulina californiensis Trujillo.

(Plate 6, figure 7.)

Lingulina californiensis TRUJILLO, 1960, Jour. Paleo., vol. 34, no. 2, p. 314, pl. 45, figs. 8 a, b.

This is a rare species in the Hex formation and was found only at no. 7 of Hex Creek. It appears to be identical to Trujillo's species from the upper Cretaceous Coniacian of the Sacramento Valley, California. Length .45 mm.

Lingulina tenera Bornemann.

(Plate 3, figure 1.)

Lingulina tenera BORNEMANN, 1854, Göttingen, p. 38, pl. 3, fig. 24. BARTENSTEIN and BRAND, 1951, Abh. senckenb. naturf. Ges., no. 485, p. 301, pl. 8, fig. 194 a, b.

Of infrequent occurrence in the Devils Den series from stations nos. 2 to 5. Not found at Hex Hill. Reported from as low as the Lias in Europe. Length .59 mm.

Subfamily MENKENINAE Church, new subfamily

Genus *Menkenina* Church, new genus

TYPE SPECIES: *Menkenina berryi* Church, new species.

The new genus has the usual characters of the uncoiled members of the family. Test calcareous, perforate with a linear arrangement of the chambers, differs from *Fronicularia* in having rounded sutures with a gentle upward curve on the ventral side and curving upward in a broad, inverted "V" on the dorsal side, test differs from *Vaginulina* in being compressed dorso-ventrally rather than laterally and in having a rounded aperture at the end of a tapered, tubular neck located at the extreme edge of the dorsal side the trace of which persists as a central welt on the dorsal side, the genus may have evolved from a *Vaginulina*-like ancestor as suggested by some specimens which are more rounded and inflated on the ventral side, test normally ornamented with a variable number of broken and continuous, longitudinal, carinate carinae extending from the initial end to the penultimate chamber, becoming less prominent

with growth, one of these forming a thin, translucent flange on the edges of the test. The new name is in honor of the late Mr. F. A. Menken¹ who first brought this fauna to my attention.

Menkenina berryi Church, new species.

(Plate 3, figures 9 a, b.)

Test free, calcareous, perforate, lanceolate, uniserial, compressed from front to back in contrast to *Vaginulina*, generally flattened on the dorsal side gently rounded on the ventral side, sutures curved upward on the ventral side, gently depressed in last and next to last chambers, flush in earlier ones, chambers lunate on ventral side, chevron-shaped on dorsal side with sutures merging with the trace of the tubular neck of the previous chamber, apertural end drawn out into a short, tapering neck at the extreme edge of the dorsal side, aperture rounded and simple at the end of the tubular neck which is, at least in part, retained in each added chamber and forms what appears to be a continuous tube near the surface, a thin transparent carina extends along each side of the test from the base of the final chamber to the initial end, usually broken and irregular, in the megalospheric form the initial chamber is large and globular followed by six lunate, alightly inflated chambers which increase regularly with growth, the initial chamber of the microspheric form is also spherical but much smaller resulting in a more sharply pointed initial end, several strong, broken to continuous costae extend longitudinally over both sides of the test from the penultimate chamber to the initial end, becoming more prominent and carinate toward the initial end but absent from the final, more inflated chamber, test straight but with a suggestion of a gentle upward curve at the initial end on the ventral side. Length 1.17 mm., width .37 mm.

HOLOTYPE no. 12977 (California Academy of Sciences, Department of Geology Type Collection) from Locality 40091 (CAS), from a deep north-south trending V-shaped gully beginning 500 feet south and 700 feet west of the east quarter corner of Section 20, Township 25 south, Range 18 east. Mount Diablo base and meridian, Devils Den area, Kern County, California. Sample no. 6, east bank of gully near base, approximately 200 feet north of the mouth of the gully; C. C. Church collector; early Cretaceous.

REMARKS. This species was found at stations 1, 2, 5, 6, of Localities 40091 (CAS) and no. 49 (F. A. Menken), Devils Den, also at Locality 27605 (CAS), south slope of Hex Hill, Kern County, California. It does not occur in abundance in any of these localities.

The specific name is in honor of Mr. Keith D. Berry of the Standard Oil Company, Oildale, California, author of new stage names for the early Cretaceous of California.

¹ Geologist and later Vice President in charge of Exploration for Tidewater Oil Company. Died in San Francisco, California, May 4, 1965.

Plate 5

All specimens illustrated on this plate are in the California Academy of Sciences, Department of Geology Type Collection.

FIGURE 1. *Vaginulina recta* Reuss. Length .72 mm.; side view. Hypotype no. 12993 (CAS). From Locality 40091 (CAS), sample 6, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 545.

FIGURE 2. *Vaginulina octocostata* Church, new species. Length .78 mm., width .17 mm.; side view. Hypotype no. 12994 (CAS). From Locality 40091 (CAS), sample 8, deep north-south gully, east side of Devils Den, sample farthest north from mouth, NW. Kern County, California. Page 546.

FIGURE 3. *Vaginulina recta* Reuss. Length .57 mm.; side view. Hypotype no. 12995 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 545.

FIGURE 4. *Nodosaria elegantia* Lalicker. Length .55 mm.; side view. Hypotype no. 12996 (CAS). From Locality 40091 (CAS), sample 6, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 541.

FIGURE 5. *Nodosaria elegantia* Lalicker. Length .80 mm.; side view. Hypotype no. 12997 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 541.

FIGURE 6. *Fronidularia species*. Length .73 mm.; side view. Hypotype no. 12998 (CAS). From Locality 40091 (CAS), sample 6, deep north-south gully east side of Devils Den, NW. Kern County, California. Page 559.

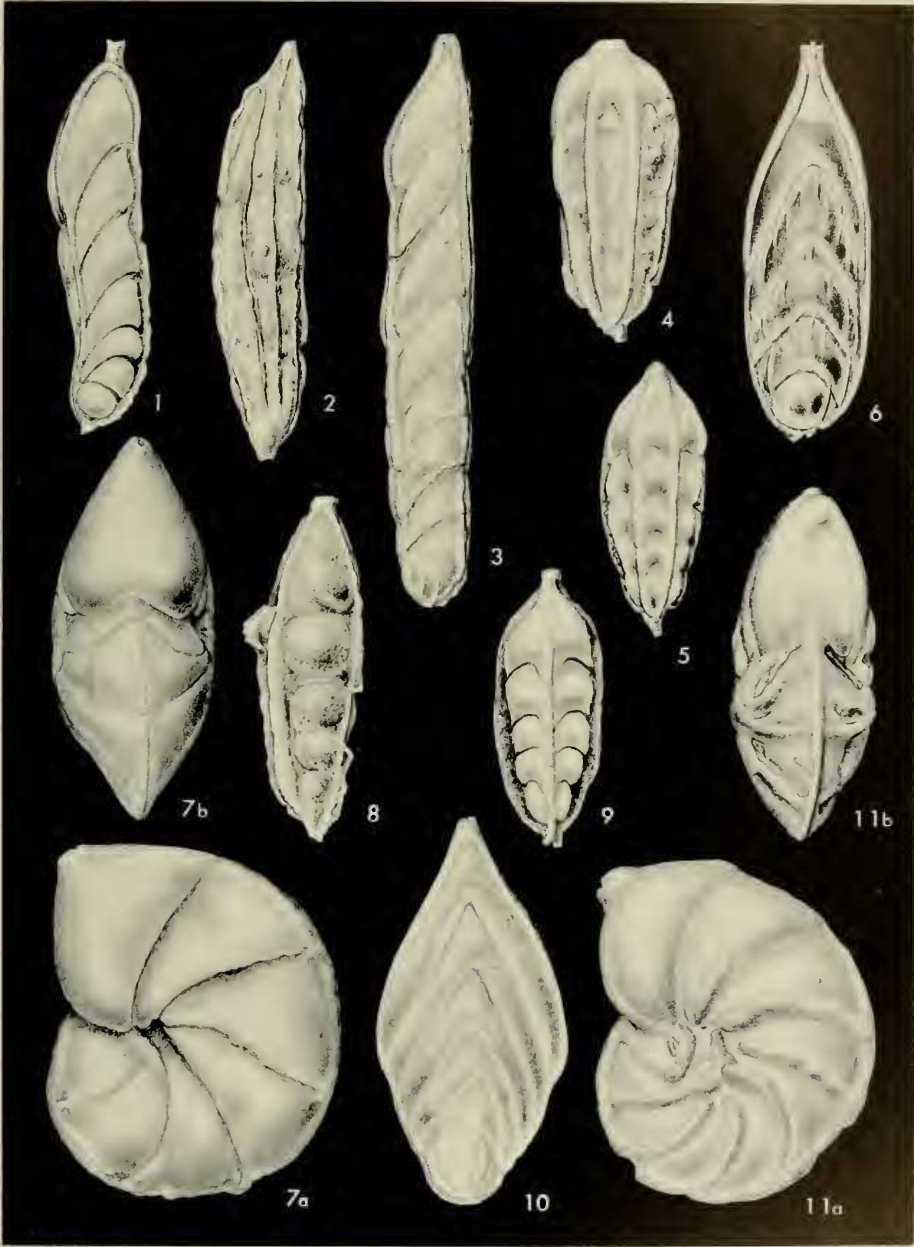
FIGURE 7. *Lenticulina (Lenticulina) münsteri* (Roemer). Length 1.34 mm.; (a) side view; (b) apertural view. Hypotype no. 12999 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 552.

FIGURE 8. *Quadratina strombecki* (Reuss). Length .51 mm.; side view. Hypotype no. 1300 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 563.

FIGURE 9. *Tristix acutangulum* (Reuss). Length .78 mm.; side view. Hypotype no. 13001 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 563.

FIGURE 10. *Fronidularia species 2*, Bartenstein, Bettenstaedt, and Bolli. Length 1.22 mm.; side view. Hypotype no. 13002 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 559.

FIGURE 11. *Lenticulina saxonica saxonica* Bartenstein and Brand. Length 1.29 mm.; (a) side view; (b) apertural view. Hypotype no. 13003 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 552.



Family GLANDULINIDAE Reuss, 1860

Subfamily GLANDULININAE

Genus *Quadratina* Ten Dam, 1946*Quadratina strombecki* (Reuss).

(Plate 5, figure 8.)

Quadratina strombecki (REUSS), 1863, Hils u. Gault, p. 56, pl. 5, fig. 3. BARTENSTEIN and BRAND, 1951, Abh. senckenb. naturf. Ges., no. 485, p. 314, pl. 10, figs. 264 a, b, c.

Only a few of this species were found and at one station, no. 7 of Hex Creek. Bartenstein and Brand reported it from the upper Valanginian of northwest Germany. Loeblich and Tappan believe this form to be a quadrate variant of the genus *Tristix* which it may be as both were found at station no. 7 of Hex Creek and except for the difference in the number of sides, are very similar in size and in being composed of clear shell material. Length .51 mm.

Genus *Tristix* Macfadyen, 1941*Tristix acutangulum* (Reuss).

(Plate 5, figure 9.)

Tristix acutangulum (Reuss), TEN DAM, 1948, Jour. Paleo., vol. 22, no. 2, p. 181, pl. 32, figs. 9, 10.

This is one of the rarer species in this fauna but the few found are very well preserved. The angles are sharply carinate with thin transparent flanges extending the length of the test. The sutures are well incised and the chambers moderately inflated. The more mature specimens have six chambers with the greatest width at the fourth chamber. The largest specimens are about 1 mm. in length and .3 mm. in width. The species was found only at station no. 7 of Hex Creek. Length .78 mm.

Family POLYMORPHINIDAE d'Orbigny, 1839

Subfamily POLYMORPHININAE d'Orbigny, 1839

Genus *Guttulina* d'Orbigny in de la Sagra, 1839*Guttulina* species.

(Plate 7, figures 3 a, b.)

Individuals representative of this family are few in number in the Hex formation and as a rule quite small. Some of the smaller, more rounded species are so similar to the small, *Nodosaria-Glandulina*-like species that they are difficult to segregate with any assurance. A few specimens were found at station no. 5 of Devils Den and a few at no. 7 of Hex Creek.

Plate 6

All specimens illustrated on this plate are in the California Academy of Sciences, Department of Geology Type Collection.

FIGURE 1. *Fronicularia frankei* Cushman. Length 3.19 mm.; side view. Hypotype no. 13004 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 557.

FIGURE 2. *Dentalina* species. Length 1.90 mm.; side view. Hypotype no. 13005 (CAS). From Locality 40091 (CAS), sample 6, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 545.

FIGURE 3. *Nodosaria* cf. *N. tenuicosta* Reuss. Length 1.15 mm.; side view. Hypotype no. 13006 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 543.

FIGURE 4. *Vaginulina debilis* (Berthelin). Length 1.64 mm.; side view. Hypotype no. 13007 (CAS). From Locality 40091 (CAS), sample 8, deep north-south gully, east side of Devils Den, sample farthest north from mouth, NW. Kern County, California. Page 546.

FIGURE 5. *Nodosaria* cf. *N. tenuicosta* Reuss. Length .92 mm.; side view. Hypotype no. 13008 (CAS). From Locality 40091 (CAS), sample 8, deep north-south gully, east side of Devils Den, sample farthest north from mouth, NW. Kern County, California. Page 543.

FIGURE 6. *Vaginulina octocostata* Church, new species. Length .86 mm.; side view. Hypotype no. 13009 (CAS). From Locality 40091 (CAS), sample 8, deep north-south gully, east side of Devils Den, sample farthest north from mouth, NW. Kern County, California. Page 546.

FIGURE 7. *Lingulina californiensis* Trujillo. Length .45 mm.; side view. Hypotype no. 13010 (CAS). From Locality 40081 (CAS), and 27501, 47 (FAM). East-west gully $\frac{1}{2}$ mile east of Devils Den, NW. Kern County, California. Page 560.

FIGURE 8. *Marginulina sigali* Bartenstein, Bettenstaedt and Bolli. Length .61 mm.; side view. Hypotype no. 13011 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully east side of Devils Den, NW. Kern County, California. Page 549.

FIGURE 9. *Marginulinopsis gracillissima* Reuss. Length .49 mm.; side view. Hypotype no. 13021 (CAS). From Locality 40091 (CAS), sample 6, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 551.

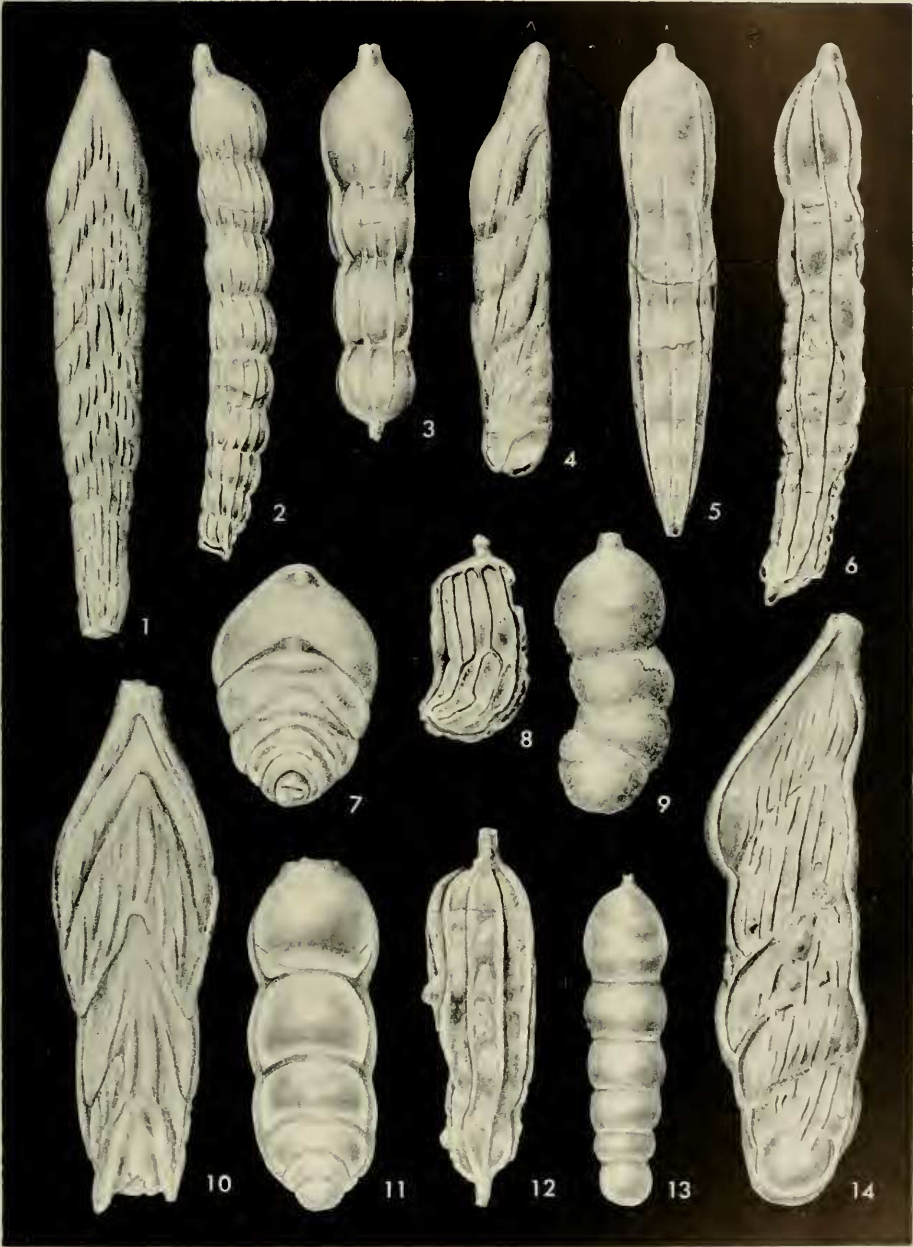
FIGURE 10. *Fronicularia frankei* Cushman. Side view. Hypotype (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 557.

FIGURE 11. *Lingulina* species. Length .52 mm.; side view. Hypotype no. 13013 (CAS). From Locality 40091 (CAS), sample 6, deep north-south gully, east side of Devils Den, NW. Kern County, California.

FIGURE 12. *Marginulina pyramidalis* Koch. Length 1.09 mm.; side view. Hypotype no. 13014 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 549.

FIGURE 13. *Nodosaria hexensis* Church, new species. Length 1.01 mm.; width .24 mm.; side view. Holotype no. 13015 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 544.

FIGURE 14. *Vaginulina striolata* (Reuss). Length 1.07 mm.; side view. Hypotype no. 13016 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 547.



Genus **Globulina** d'Orbigny in de la Sagra, 1839**Globulina** cf. **G. ampulla** (Jones).

(Plate 8, figure 4.)

Polymorphina ampulla JONES, 1852, Quart. Jour. Geol. Soc., vol. 8, p. 267, pl. 16, fig. 14.*Polymorphina lactea* PLUMMER, 1927, Bull. 2644, Univ. Texas, p. 121, pl. 6, figs. 7 a-c.*Globulina ampulla* (Jones), CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, no. 2829, p. 79, pl. 19, figs. 9 a-c.

There is considerable variation in these lower Cretaceous species. Most specimens are well rounded and globular but some compressed. The lower initial end is distinctly pointed in some but only suggested in most of them. It is a fairly common species at station no. 5 of Devils Den. Length .48 mm.

Globulina prisca Reuss.*Globulina prisca* REUSS, 1862 (1863), Stiz. Akad. Wiss. Wien, vol. 46, pt. 1, p. 79, pl. 9, fig. 8. CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, no. 2829, p. 73, pl. 12, figs. 6 a-c.

This is not a common species here and was found only at station no. 5 of Devils Den.

Genus **Pseudopolymorphina** Cushman and Ozawa, 1928**Pseudopolymorphina** cf. **P. leopolitana** (Reuss).*Polymorphina leopolitana* REUSS, 1851, Haidinger's Nat. Abhandl., vol. 4, p. 28, pl. 4, fig. 11.*Pseudopolymorphina leopolitana* (Reuss), CUSHMAN and OZAWA, 1930, Proc. U. S. Nat. Mus., vol. 77, no. 2829, art. 6, p. 108, pl. 28, figs. 4 a-c.

This is an extremely rare species as only one was found at station no. 7 of Hex Creek.

Genus **Pyrulina** d'Orbigny, 1826**Pyrulina** species.

(Plate 7, figure 5.)

A single, well preserved specimen of the genus was found at station no. 5 of Devils Den. Length 1.16 mm.

Subfamily RAMULININAE, Brady, 1884

Genus **Ramulina** Jones in Wright, 1875**Ramulina spandeli** Paalzow.*Ramulina spandeli* PAALZOW, 1917, Schwammgerel, p. 46, pl. 47, fig. 15. BARTENSTEIN, BETTENSTADT, and BOLLI, 1957, Eclog. Geol. Helv. vol. 50, no. 1, p. 42, pl. 5, fig. 106.

This is not an uncommon species at Devils Den stations nos. 1, 2, and 5 but in most of its occurrences it is found in fragments.

Family NONIONIDAE Schultze, 1854

Subfamily CHILOSTOMELLINAE

Genus *Quadrिमorphina* Finlay, 1939*Quadrिमorphina* cf. *Q. ruckeri* (Tappan).

(Plate 8, figures 1 a, b, c; 2 a, b.)

Pallaimorphina ruckeri TAPPAN, 1957, U. S. Nat. Mus., Bull., 215, p. 221, pl. 71, figs. 1-9.

This very small species is very similar to *Q. albertensis* Mellon and Wall but the chambers are much less inflated. It was found rather commonly at stations 4 and 5 of Devils Den but not at Hex Hill. Length .18 mm.

Family ALABAMANIDAE Hofker, 1951

Genus *Gyroidina* d'Orbigny, 1826*Gyroidina globosa* (Hagenow) Cushman.

(Plate 8, figures 3 a, b, c.)

Nonionina globosa HAGENOW, 1842, Neues Jarb., p. 574.*Rotalia globosa* REUSS, 1861, Akad. Wiss. Wien, Math. naturwiss. Kl. Sitzungsber., vol. 44, pt. 1, p. 330, pl. 7, figs. 2 a, b.*Gyroidina globosa* CUSHMAN, 1931, Jour. Paleo., vol. 5, no. 4, p. 310, pl. 35, figs. 19 a-c.

This long-ranging species is one of the commoner forms at stations nos. 7 and 8 of Hex Creek and no. 15 of Hex Hill. Length .40 mm.

Superfamily CASSIDULINACEA d'Orbigny, 1839

Family ANOMALINIDAE

Subfamily ANOMALININAE

Genus *Gavelinella* Brotzen, 1942*Gavelinella barremiana* Bettenstaedt.

(Plate 8, figures 6 a, b, c.)

Gavelinella barremiana BETTENSTAEDT, 1952, Senckenbergiana, vol. 33, no. 4/6, p. 275, pl. 2, figs. 26-29. BARTENSTEIN, BETTENSTAEDT, and BOLLI, 1957, Eclog. Geol. Helv., vol. 50, no. 1, p. 47, pl. 7, figs. 168 a-c; 169 a-c.

This is one of the common species in samples 7 and 8 of Hex Creek. It was also found at no. 15 of Hex Hill. The species was described from the middle Barremian of Germany by Bettenstaedt but ranges somewhat higher. It has also been described from the lower Cretaceous of Trinidad, British West Indies. Length .47 mm.

Family CIBICIDIDAE Cushman, 1927
Subfamily PLANULININAE Bermudez, 1952
Genus *Planulina* d'Orbigny, 1826

Planulina andersoni Church, new species.

(Plate 8, figures 7 a, b, c.)

Test trochoid, biconvex, dorsal side gently convex, ventral side compressed but with a slight convexity and central depression, periphery subacute, partially evolute on dorsal side, involute or nearly so on the ventral side, periphery only faintly lobulate, chambers distinct throughout, 12 in final whorl, uninflated and increasing gradually and uniformly as added, sutures broad, strongly recurved and prominent because of lighter color and elevation above the chamber surface near the outer curve of test, sutures tend to merge at outer edge to form a smooth edged keel, wall perforate, smooth, aperture a low arch with narrow bordering lip at the peripheral margin, extending a short distance into the umbilical area on the ventral side. Length .42 mm., width .33 mm.

HOLOTYPE no. 13033 (California Academy of Sciences, Department of Geology Type Collection), from Locality 40091 (CAS), from deep north-south trending V-shaped gully beginning 500 feet south and 700 feet west of the east quarter corner of Section 20, Township 25 south, Range 18 east, Mount Diablo base and meridian, Devils Den area, Kern County, California. Sample no. 5, east bank of gully near base, approximately 150 feet north of the mouth of the gully; C. C. Church collector; early Cretaceous.

REMARKS. This species is fairly common where it occurs at the Devils Den locality at stations nos. 1 to 5 but was not found at Hex Hill. It is somewhat similar to *Anomalina popenoei* Trujillo from the upper Cretaceous of the Sacramento Valley, California and also bears a general resemblance to *Planulina spissocostata* Cushman from the Taylor marl of Texas, U. S. A. From the former it differs in having more chambers, a smoother periphery and being less sharply keeled and from the latter in having fewer chambers per whorl, a more rounded keel and no buildup of calcite near the umbilicus. Named in honor of the late Dr. F. M. Anderson.

Superfamily ORBITOIDACEA Schwager, 1876
Family EPONIDIDAE Hofker, 1951
Genus *Eponides* de Montfort, 1808

Eponides species.

This is one of the rare species in the Devils Den assemblage and the only representative of the genus found in this lower Cretaceous fauna. It is of moderate size, trochospiral, about equally biconvex, four slightly lobed chambers visible on the ventral side, edge smoothly rounded. Found only at stations nos. 4 and 5 of the Devils Den series.

Plate 7

All specimens illustrated on this plate are in the California Academy of Sciences, Department of Geology Type Collection.

FIGURE 1. *Praeulimina* species. Length .32 mm.; (a) side view; (b) end view. Hypotype no. 13017 (CAS). From Locality 40091 (CAS), sample 4, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 570.

FIGURE 2. *Globanomalina hexensis* Church, new species. Length .28 mm.; width .22 mm.; (a) side view; (b) apertural view. Holotype no. 13018 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 571.

FIGURE 3. *Guttulina* species. Length .71 mm.; (a) side view; (b) apertural view. Hypotype no. 13019 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 563.

FIGURE 4. *Hedbergella planispira* (Tappan). Length .21 mm.; (a) ventral view; (b) dorsal view; (c) apertural view. Hypotype no. 13020 (CAS). From Locality 40095 (CAS), sample 7, Hex Creek, NW. edge of Hex Hill, NW. Kern County, California. Page 571.

FIGURE 5. *Pyrulina* species. Length 1.16 mm.; side view. Hypotype no. 13021 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 565.

FIGURE 6. *Involutina stinemeyeri* Church, new species. Length .44 mm.; width .41 mm.; side view. Holotype no. 13022 (CAS). From Locality 40091 (CAS), sample 6, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 565.

FIGURE 7. *Nodosaria humilis* Roemer. Length .69 mm.; side view. Hypotype no. 13023 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 541.

FIGURE 8. *Gubkinella californica* Church, new species. Length .19 mm., width .15 mm.; side view. Holotype no. 13024 (CAS). From Locality 40091 (CAS), sample 6, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 573.

FIGURE 9. *Ammodiscus glabratus* Cushman and Jarvis. Length .61 mm.; side view. Hypotype no. 13025 (CAS). From Locality 40092 (CAS), west side of most easterly deep gully of Hex Hill, NW. Kern County, California. Page 533.

FIGURE 10. *Darbyella* species. Length .69 mm.; (a) dorsal view; (b) ventral view; (c) apertural view. Hypotype no. 13026 (CAS). From Locality 40091 (CAS), sample 5, deep north-south gully, east side of Devils Den, NW. Kern County, California. Page 555.